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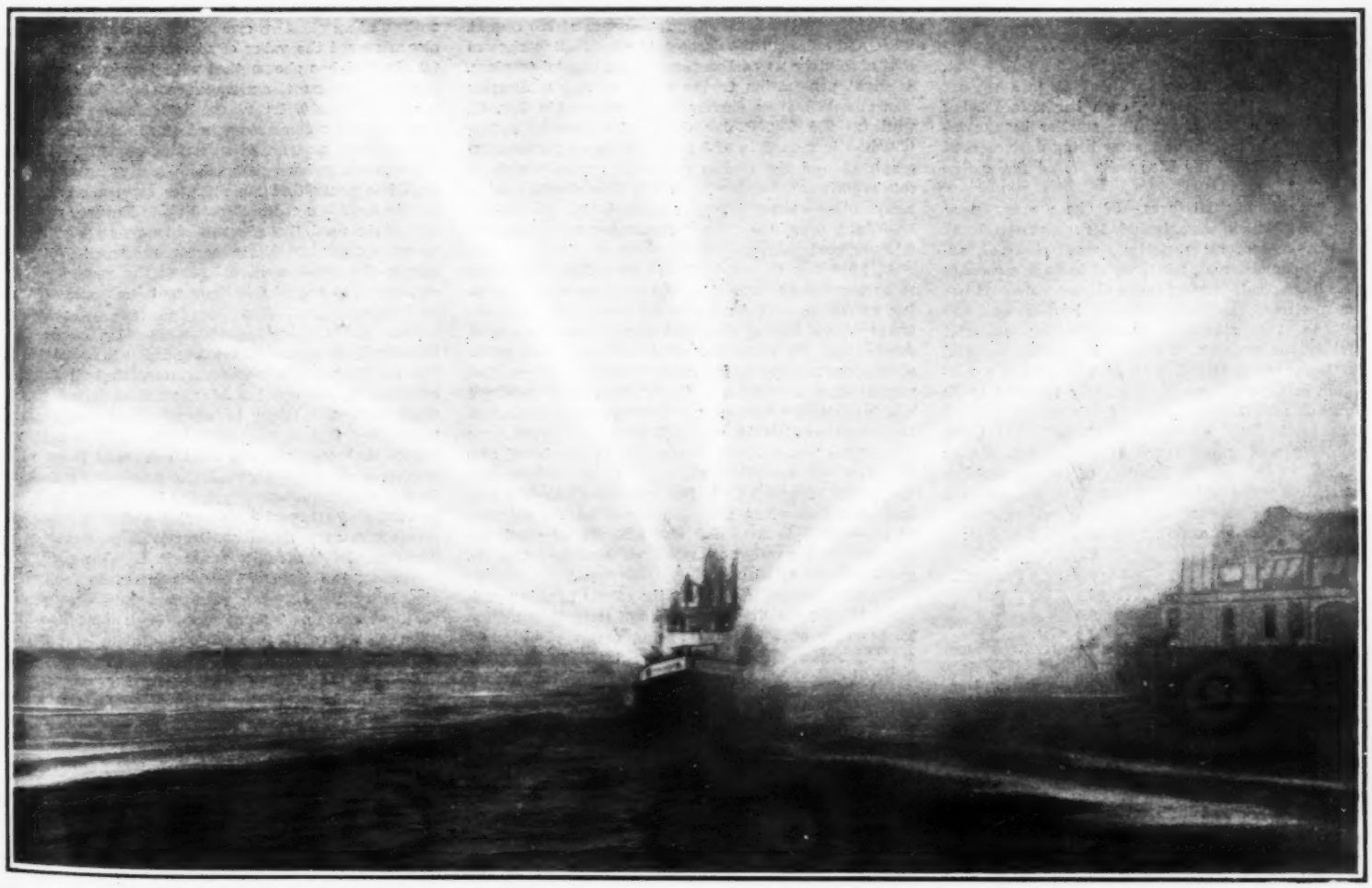
THE FIRE BOAT'S EFFICIENCY IS NOT LIMITED TO THE WATER FRONT. THE BOAT MAY FORCE WATER A QUARTER OF A MILE THROUGH A HOSE, DELIVERING IT TO A FIRE ENGINE TO BE DIRECTED ON THE BLAZE.



A FIRE BOAT AT FULL PRESSURE, SHOWING THE ENORMOUS AMOUNT OF WATER IT CAN THROW, AND ITS MANY JETS.

FIRE BOAT PROTECTION.—[SEE PAGE 329.]

# THE CASE HARDENING OF STEEL.*

## WHAT IT IS AND HOW IT IS DONE.

BY G. SHAW SCOTT.

THE process known as case hardening is one which consists of adding such a percentage of carbon to a relatively thin outside layer of iron or mild steel as will, on correct quenching, produce a hardened surface, while the inner core of the metal still retains its initial character.

Case hardening is conducted in practically all engineering works, but, generally speaking, it appears that comparatively little is known of the theory of the process by those who practise the operation, and up to quite recent years crude rule of thumb methods were almost universally applied. The production of satisfactory case-hardened material is a matter of supreme importance to many engineering undertakings, and especially to such industries as cycle and motor-car making, in which there is often required very hard, yet tough, material in order to obtain satisfactory results in every-day use.

Among the many mechanical parts produced by the above industries which require to be case hardened are free-wheels, chains, gudgeon pins, roller and ball bearings, bushes, parts of camshafts, steering-gear pins, gear wheels of all kinds, valve levers, etc.

Case hardening is fundamentally the same as the older process of cementation, the chief points of difference being that in case hardening a different carbon-conveying material is used from that generally employed in cementation, while in the latter process the carbon is allowed to penetrate through, or nearly through, the bars, and is not interrupted so as to form merely a surface or "case" of carburized metal. Case hardening is somewhat allied to the Harveyizing and Krupp processes, both of which are employed for the hardening of armor plate. In the former process a solid carbonaceous cementing material is employed, usually charcoal, and in the latter a gaseous hydrocarbon is stated to replace the charcoal.

The materials used in experiments were:

1. Steel.—For the purposes of this research, a variety of steel was selected which has been found by experience in the trade to be especially suitable for case hardening. On analysis, this steel was found to have the following composition:

| | Per cent. |
|---|---|
| Combined carbon | 0.14 |
| Silicon | 0.01 |
| Sulphur | 0.08 |
| Phosphorus | 0.03 |
| Manganese | 0.58 |
| Iron (by difference) | 99.16 |
| Total | 100.00 |

The steel was delivered in lengths of about 3 feet, and had been rolled down to about ¼ inch square. For experimental convenience, each bar before being used was cut up into about nine smaller bars, averaging 4 inches in length, and, after being duly marked for future reference, the bars were stored for use as required.

2. Case-Hardening Mixtures.—Of these many were tried, among which were included such materials as burnt leather (several varieties), wood charcoal, anthracite, sugar charcoal, mixtures of barium carbonate and wood charcoal. Owing to its almost universal use in trade circles in England burnt leather was employed as the standard case-hardening material throughout the research. Two samples of this material in particular were tested, both of which have a considerable sale. They are subsequently referred to as mixtures A and B.

Since preliminary experiments showed that there undoubtedly was a difference in the case-hardening effect, due to the relative fineness of the carbonizing material, it was thought desirable first to ascertain the coarseness of the mixture used, and the following table gives the result of an examination of both A and B:

| | A. Per cent. | B. Per cent. |
|---|---|---|
| Does not pass 10 sieve | 68.0 | 72.6 |
| Does not pass 20 sieve | 9.0 | 9.6 |
| Does not pass 30 sieve | 4.2 | 5.8 |
| Does not pass 60 sieve | 4.4 | 5.4 |
| Does not pass 90 sieve | 4.0 | 3.8 |
| Does pass 90 sieve | 9.4 | 2.6 |
| Totals | 99.0 | 99.8 |

From the above it will be seen that practically 75 per cent of the material was comparatively coarse, and that there was rather a high proportion of very fine material in A, as compared with B. Sample B was found to contain a considerable amount of unburnt or only partly burnt material, and this is a feature in a case-hardening material that does not tend to reliable work. Estimations of moisture and ash were made in the case of both these mixtures with the following results:

| | Moisture. Per cent. | Ash. Per cent. |
|---|---|---|
| A | 13.44 | 5.56 |
| B | 24.68 | 3.60 |

As a result of these experiments, the mixture A was decided on as standard, and an estimation of the amount of nitrogen present was made by Kjeldahl's method, 1 grain of the material being digested with strong sulphuric acid. The acid solution was then heated with excess of sodium hydrate, and the evolved ammonia was absorbed in a known volume of standard acid and determined volumetrically. The mean of several results showed that nitrogen was present to the extent of 3.2 per cent. The composition of our standard case-hardening material A can, therefore, be represented as follows:

| | Per cent. |
|---|---|
| Carbon (by difference) | 77.80 |
| Nitrogen | 3.20 |
| Moisture | 13.44 |
| Ash | 5.56 |
| | 100.00 |

3. Boxes.—For the purpose of heating the experimental bars in contact with the case-hardening mixtures a number of iron boxes were cast in the Birmingham University Foundry. Their length inside was 4 inches; breadth, 2 inches; depth, 1 inch, and thickness, ¼ inch. Boxes made of fire clay were used in preliminary tests, but the cast-iron articles were found to be much more satisfactory.

4. Muffles.—These were of a recent Morgan type, heated by Mond gas, and capable of giving a temperature of 1,000 deg. C. The temperature of the muffles was recorded by means of a direct-reading Baird & Tatlock thermo-couple pyrometer, the accuracy of which was frequently tested by the usual methods.

The first experiments dealt with the influence of time and temperature upon carbon absorption, employing the standard mixture, A, of which the composition has already been given.

In connection with case-hardening temperatures, it may be pointed out that Mr. Osmond's work has shown that iron does not absorb carbon to any considerable extent below the recalescence point, Ar3, or, in other words, that the lowest practicable temperature, using pure iron and pure carbon, will be not much below 900 deg. C., a statement which was checked as follows: Bars were heated for four hours at 700 deg. C. in A, and subsequent microscopic examination showed that absolutely no carbon penetration had taken place. A slight penetration to the depth of 0.13 millimeter was observed after similar treatment at 800 deg. C., while at 900 deg. C. the depth of carbon impregnation had increased to 1.58 millimeters. A photomicrograph showed the carbon penetration resulting from this experiment, the ferrite, which showed white originally, disappearing. The case hardening was about 1/16 inch deep, the "case" containing approximately 0.89 per cent carbon.

At 1,000 deg. C. the depth of penetration was found to be more than twice that obtained by case hardening at 900 deg. C. for an equal length of time. At temperatures higher than 900 deg. C. the danger of overheating the metal was evidenced, and the carbon absorption became both "harsh" and irregular. For normal case hardening a "case" should be obtained which contains a percentage of carbon equal to that of the pearlite eutectoid, viz., 0.89 per cent. With more carbon the "case" in its "normal" or unhardened condition shows cementite as white rivers surrounding the larger masses of pearlite when the polished surface of the specimen has been etched with a solution of picric acid in alcohol. The presence of much cementite is generally regarded as unsatisfactory in case-hardened articles.

We now proceed to consider the effects of using various mixtures for differing periods of time, the uniform temperature of 900 deg. C. being employed throughout the series. Using specimens 3 inches long and 6.5 millimeters square sections, the following figures were obtained:

| Time of Heating, Hours. | Burnt Leather A, Millimeters. | Wood Charcoal, Millimeters. | Barium Carbonate and Wood Charcoal, Millimeters. |
|---|---|---|---|
| 2 | 1.15 | 0.72 | 1.36 |
| 4 | 1.58 | 1.07 | 2.20 |
| 8 | 2.30 | 1.58 | 2.84 |
| 12 | 2.80 | 1.80 | 3.17 |
| 16 | Right across specimen. | | |

It will be seen that the most rapid penetration took place when using the mixture consisting of barium carbonate and wood charcoal, while the least penetration resulted from the use of wood charcoal. However, when the heat was sufficiently prolonged the several mixtures gave approximately the same results.

Case-hardening materials, as previously stated, are varied in character, and include such substances as wood charcoal, potassium ferrocyanide, potassium cyanide, petroleum gas, bone, horn, graphite, burnt leather, bone black, acetylene, barium carbonate and charcoal, coal gas, sugar charcoal, etc. What is most noteworthy in connection with this list is that of all the materials mentioned, those that give the most rapid case-hardening effect either contain nitrogen in some form or other, or else have the power of utilizing atmospheric nitrogen. The effects of nitrogen on case hardening are exceedingly important and will be discussed later.

In the case of a non-nitrogenous material, such as sugar, charcoal, or anthracite, it is usually assumed that the case-hardening action comes about in the following way. Air in the cementing box unites with the carbon, forming carbon monoxide, which gas reacts upon the iron, thus:

$$2CO + 3Fe = Fe_3C + CO_2.$$

The liberated carbon dioxide acts upon a further portion of carbon, producing still more of the monoxide:

$$CO_2 + C = 2CO.$$

Thus the process is continuous, and the carbon monoxide will continue to carry carbon into the metal until the latter becomes saturated. It was, however, shown by Sir W. Roberts-Austen that pure iron and pure carbon can unite without any intermediate action of carbon monoxide, while Prof. Arnold considers that the subcarbide ($F_3C$) plays an important part in the carburization of iron or steel.

As regards cyanides, these are not much used for case hardening, except for small work that requires merely a skin hardness, but a mixture which may depend upon cyanogen products for its effectiveness has been successfully adopted by Dr. Guillet in France. This consists of 60 per cent of wood charcoal and 40 per cent of barium carbonate, and its effectiveness has been substantiated by the author of this paper, as is shown by the figures already given.

Dr. Guillet suggests that this increased case-hardening effect is due to some property of barium carbonate which enables it to absorb nitrogen with the formation of an effective cyanide of barium. Braune has also observed the value of nitrogenous cementing materials, and has shown that with iron containing 0.35 per cent carbon the nitrogen content in the "case" increased from 0.01 per cent before cementing to 0.07 per cent after cementing, but this large increase occurs only as a result of employing a nitrogenous substance, such as bone charcoal. When using wood charcoal, it appears that the nitrogen increases only from 0.01 to 0.024 per cent. According to Braune, whatever cement be used the effect of subsequent reheating is to cause a gradual diminution in the amount of nitrogen in the metal, and so long as the amount of this gas does not exceed 0.035 per cent the metal will not be brittle.

Some of the above figures, as given by Braune, have recently been contested by two Swedish chemists, Petrén and Grabe. The latter maintains that all Braune's nitrogen figures are too high, since sufficient precautions were not taken to observe that the reagents used were free from ammonia. *Inter alia* it was shown that cast crucible steel contained more nitrogen than open hearth steel, for the reason that the former was made from cemented iron, which had been in contact for a prolonged period and at a high temperature with a slightly nitrogenous material—wood charcoal. In the same paper it is shown that in cementing the nitrogen content increases proportionately with the increase of carbon, but only up to 1 per cent carbon. The nitrogen is then at its maximum, 0.008 to 0.010 per cent, and further increments of carbon result in less nitrogen being absorbed.

All the case hardening materials in common commercial use contain nitrogen in some form or other. It is obvious that unless practical experience had shown that nitrogen aided the process in some way no one would think of using a costly nitrogenous material in place of charcoal or anthracite, these being well-known possible substitutes, which cost only as much per ton as burnt leather costs per hundredweight.

To prove how slight was the effect (measured by carbon penetration) of heating our standard steel bar with materials other than those which contain or supply nitrogen, experiments were made with anthra-

* From a paper read at the Vienna meeting of the Iron and Steel Institute, September, 1907.

cite, and also with good hard coke. The carbonaceous material in each case, together with the bar to be treated, was packed gently in one of the special iron boxes prepared for the research, and after being carefully luted down in the box was heated in a muffle for 4 hours at 900 deg. C. After this heating it was found that there was penetration to the following extent:

(a) Anthracite .....0.15 mm. on 6.5 mm.
(b) Best hard coke.....0.16 mm. on 5.5 mm.

As a result of heating a bar under exactly similar conditions, but using as a carbonizing material burnt leather "a," instead of the above, a penetration of 1.5 millimeters was obtained. From this it will be seen that the effect of the nitrogenous mixture was to increase the depth of penetration during the initial stage of case hardening in the ratio of about 10 to 1. Hence it will be recognized that nitrogen must play a very important part in the process of case hardening. As a result of the consideration of the above facts relating to the possible effect of nitrogen in conducing to rapid case hardening, further experiments were undertaken, which briefly were as follows:

Two exactly similar bars of standard steel were selected. One was heated in an atmosphere of ammonia for 4 hours at 550 deg. C. The other meanwhile received no treatment. Afterward both were heated in separate cast iron boxes in a non-nitrogenous carbonaceous material (sugar carbon) for 8 hours at 1,000 deg. C. The mean figures of a series of these experiments showed that the "ammonia bar," as compared with the untreated bar, had received greater proportionate penetration in the ratio of 45 to 32. The high temperature employed was specially favorable to the non-nitrogenous material, and had the heating been conducted at a lower temperature the difference in all probability would have been still greater.

Subsequently an apparatus was made by means of which it was possible to pass dry ammonia into the case-hardening box during the whole period of heating of the muffle. For this purpose one extremity of a piece of ½-inch gas pipe some 2 feet long was screwed into the end of one of the boxes. The other extremity, which projected outside the muffle, was connected to another for giving dry ammonia. In the same muffle as the above box and placed side by side with it was an ordinary box. Both were filled with sugar charcoal as a non-nitrogenous carbonizing medium, and among the charcoal several test bars were placed. For 4 hours the muffle containing the two boxes was kept at 900 deg. C., a stream of ammonia being passed through the special box, escaping through a minute hole drilled in the lid. Afterward the boxes were allowed to cool, ammonia still passing into the special box. On subsequent superficial examination the "non-ammonia" specimens were found to be bluish black in color and quite soft to the saw. On the other hand, all the ammonia treated bars possessed a distinct whitish luster and presented a tough outer skin to the saw.

Microscopic examination enabled the depth of carbon penetration in each case to be measured. This showed that whereas the bars which had received no ammonia treatment gave a penetration figure of 1.44 millimeters, those which had been treated with the gas had been penetrated by the carbon to the extent of 1.80 millimeters.

It will thus be seen that the result of the experiments was to show that ammonia did actually cause an increase of carbon penetration, but that the amount of this increase was perhaps not quite as great as might have been anticipated under the circumstances surrounding the experiment.

Mention must be made of the peculiar results obtained by heating bars at a certain temperature in ammonia. After treatment with ammonia for 4 hours at 550 deg. C. the bars showed a bright, silvery luster, and on microscopic examination a structure at the edge of each specimen was observed which showed very obvious "twinning." That twin crystals were not present in the bars before treatment was proved by repeated and careful microscopic examination at high powers of the original material.

A uniform structure was always observed right through the bar. To show that the "twinning" was not produced by the distortion of the bar by some mechanical strain a bar was held in the vise and bent backward and forward several times until fracture occurred. No twin crystals resulted from this treatment or from violent and rapid sawing or hammering. It is therefore evident that these twin crystals were not present in the original steel, nor were they induced by any subsequent mechanical treatment, but that they were produced by heating the bars for a more or less prolonged period at 550 deg. C. in an atmosphere of ammonia.

As it appears to be abundantly clear that nitrogen in some form is necessary for the practical performance of case hardening, the question arises as to the manner in which nitrogen assists the rate of carburization. That the free gas itself has no effect upon steel has been proved, both by Guillet and by Braune. Ammonia, on the other hand, is absorbed by iron, and the experiments above recorded prove that it causes an increase in the rate of carburization when carbonaceous material is present. This latter fact suggests that ammonia itself, while being the prime agent in any change, may conceivably lead to the formation of cyanogen, and that this cyanogen may act upon the iron thus: $2CN + 3Fe_2 = 2Fe_2C + 2N$, from which it will be seen that the cyanogen may act as a carrier of carbon to the metal to be carburized.

This, however, does not explain why carburization takes place at a lower temperature when nitrogen compounds are present. But it has been shown that after steel has been treated in ammonia "twinning" is observed. Now, since Osmond has shown that twinning can only result when iron or steel is in the $\gamma$ condition, it is reasonable to assume that the metal has been changed from the $\alpha$ to the $\gamma$ state. Under normal conditions metal at 550 deg. C. would certainly be in the $\alpha$ condition. Nitrogen, we may conclude, should, therefore, be added to the list of elements which cause iron to take and retain the $\gamma$ form. And, since $\gamma$ iron combines more readily with carbon than does $\alpha$ iron, this action of nitrogen on the iron would appear to explain sufficiently its beneficial effect during the early stages of the process of case hardening.

# THE STEAMING OF TIMBER.*

## CLEANING SAP CELLS FOR PRESERVATIVES.

### BY OCTAVE CHANUTE.

Wood, in seasoning, loses a great deal of weight, and yet shrinks but little; the sap ducts lose the evaporated water, and their walls become incrusted with the non-volatile portions of the sap, among which is vegetable albumen, constituting the principal cause of decay. The albumen dried at ordinary temperature hardens into a horn-like substance, but the application of moisture and gentle heat again dissolves it, and thus re-establishes a continuity of the sap ducts. It is important to reach this result with the least possible amount of condensed water, so as to leave as many voids as practicable to be permeated by the antiseptic solution. This is best accomplished by steaming at temperatures from 212 deg. to 240 deg. F. for ten minutes to three hours, according to the kind and condition of the wood, and by following this up for some ten minutes with as great a vacuum as possible. The steam penetrates and dampens all the fibers of the wood; it heats and swells it considerably; it carries off, moreover, by a sort of washing, various volatile or soluble substances, and yet it condenses in the wood in such small quantities that the increase in weight is negligible, and sometimes more than overbalanced by the weight of matters extracted.

This, it will be noted, was predicted upon the injection of sulphate of copper, a process introduced in 1857. It is believed that steaming before the vacuum was then universally adopted in Europe by all the establishments which injected mineral salts, but those injecting creosote early recognized that the small amount of condensed steam left in the wood resisted to some extent the injection of this oily substance, and the writer believes that the present practice in Europe is not to steam wood intended to be creosoted. In England the timber, much of which has been rafted, is very thoroughly air seasoned. In France and Germany ties are stacked in open piles for ten to twelve months, during which time some 16 to 25 per cent of the weight is lost, and then they are in many cases desiccated further in drying ovens (not dry kilns), during which latter process they lose 3 or 4 per cent more of weight before being transferred warm into the creosoting cylinder. Another method is to boil the ties in hot creosote so as to evaporate the sap and make room for the creosote, which is injected by pressure. This is, perhaps, the best method, laboratory experiments showing that there is still 18 to 20 per cent of moisture in so-called "thoroughly air-seasoned timber."

For wood to be injected with mineral salts, steaming is generally resorted to in Europe, these salts being in watery solutions, and condensed steam is not objectionable, as it merely weakens the solution, which is made a trifle stronger than it would otherwise.

In the United States, Hayford took out various patents for steaming in 1859, 1870, 1872, and 1877, which were hailed as great improvements, and went into extensive use even for creosoting. For a time every wood preserver steamed before injection, and it is only within the last two or three years that the question has been raised whether better penetration with mineral salts cannot be obtained by omitting steaming altogether.

The writer having tried hundreds of experiments during the first ten or fifteen years of his practice in the injection of mineral salts, believes that whether it is advisable to steam or not to steam depends altogether upon the condition of the wood when it becomes necessary to inject it. The best practice is to season it thoroughly, but customers are generally impatient and urgently require the treated wood for immediate use. So the operator has often the alternative of either discommoding his client, or of not doing the best work of which he is capable. He not infrequently unloads timber on the ground at his own expense in order to season it a little more.

Wood structure generally contains 30 to 50 per cent of cells by volume. In the living trees these cells are filled with sap and the problem is how to replace this sap with some preservative substance. In rafting, a small part is washed out by diffusion, and in air seasoning perhaps over one-half of the watery portion of the sap slowly evaporates. It is obvious enough that, in order to inject satisfactory amounts of any antiseptic, a place for this must be found in the wood, and if the sap cells be filled with sap or with water, it is clearly impossible to fill them with another fluid. To clear the sap cells, therefore, we must produce some motive force inside the wood. This motive power may consist of steam generated inside of the wood, or it may consist of air which has replaced so much of the watery portion of the sap as has been evaporated in seasoning, which air is heated and expanded by steaming.

Proceeding upon this theory, the writer tried very many experiments with various species of wood, fresh cut, quarter seasoned, half seasoned or wholly seasoned, by steaming them various lengths of time, they being weighed in and out at each stage of the operation. He found that where the wood was fresh cut and full of watery sap, it required no less than eight hours of steaming at 20 pounds pressure (258 deg. F.) to bring the center of a tie, 6 by 8 inches section, to the boiling point, or 212 deg. F., at which the sap would begin to generate steam so as to drive out some of the watery portion. It is understood that the creosoters who operate upon fresh-cut or water-logged piles are sometimes compelled to steam for twenty-four hours, at more than 20 pounds pressure, in order to clear the wood for injection. In that case it is probably safe to begin the operation with steam as high as 30 pounds pressure (275 deg. F.) because the water in the wood, which first evaporates, protects the fiber from immediate injury, but toward the close of the operation the pressure should not exceed 20 pounds, which has been found the point (258 deg. F.) at which small injury to the strength of the fiber is likely to result.

With half-seasoned ties, that is, air dried, from four to six months, according to the time of the year, the writer ascertained the perhaps surprising fact that more sap could be extracted by one to three hours' steaming than could be gotten out of fresh-cut ties by three to five hours of steaming at 20 pounds pressure. Of course there was more of the watery portions of the sap in the fresh-cut ties than in those half seasoned, but it could not be extracted satisfactorily without much longer steaming. It was concluded that when the wood was half seasoned, some air had flowed in, and that this, being moderately heated by the steaming, expanded so as to drive out a good deal of the remaining sap, and this view was confirmed by the examination of the ties immediately upon their withdrawal from the treating cylinder, when minute bubbles of air and sap were observed issuing from the ends of the ties.

With fully seasoned ties, say six to twelve months from the cutting, the effect of steaming was sometimes to increase the weight of the ties, and sometimes to diminish it, such increase or loss being, however, very small and well within 2 per cent. It was found that when the ties were in that condition it was best to dispense with the steaming altogether, and to begin with the vacuum, as more solution (chloride of zinc in this case) could be injected than when the ties were previously steamed, which latter operation leaving some condensed steam in the wood (say, perhaps, 5 per cent of its weight reduced to 2 per cent by the subsequent vacuum) diminished by just so much the quantity of solution which could be forced into the tie.

These experiments were made from 1890 to 1900,

* Abstracted from an address before the National Association of Wood Preservers.

and were fully confirmed by experiments made in 1904 by Mr. S. M. Rowe. From the results and from experience gained in regular working, the following practice has grown up at the works of the writer:

1. To refuse to treat fresh-cut ties, but to put them on the ground to season.

2. To begin the spring season's treating by steaming, unless the ties are of previous year's cutting.

3. To omit steaming in the summer and autumn, when the ties prove to be well seasoned.

This practice leaves open the question whether it is important for the best results to first sterilize the germs of decay by heat, either that of steam or that of hot air by drying ovens. Some bacteriologists hold that the germs of decay exist in sap of the wood before it is cut down, and some believe that these germs penetrate into the wood after it is treated. The writer's experience with the results of ties previously steamed or treated without steaming, is not sufficient to enable him to adduce any facts bearing on this question; but he believes that the European practice of heating wood in drying ovens just prior to its injection is good, and that this may be the next improvement which should be introduced in this country.

# ELEMENTS OF ELECTRICAL ENGINEERING.—V.

## CONSTANT-POTENTIAL GENERATORS.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1662, page 295.

ON account of the particular sort of lighting to which machines of this sort were first applied, they were originally called "incandescent" dynamos. Such a title is altogether too narow to embrace the wide field now covered by these general utility machines.

By referring to some of the principles explained in earlier chapters, it will be observed that the inherent factors involved in dynamo construction tend toward constancy of potential. Electromotive force being proportional to the product of the number of lines of force of the field magnet by the number of armature conductors and by the speed, the provision of making these three quantities constant would at once seem to require no further provisions. Indeed, the conditions would fully be filled, were no load or a constant load applied. Variable loads are, of course, the ordinary experience, with such accompanying actions and reactions as really to make unavoidable variations in the three quantities just mentioned. The act of increasing the load on a constant potential generator, demanding more current, results in greater armature demagnetizing components, thereby cutting down the effective field flux, and requiring a lead to be given the brushes, which relocation reduces sparking, but cuts down the effective number of armature conductors; the application of the load ordinarily results in some diminution of speed in the motive power. The combined effect of these three factors will be to exaggerate each other, so that without special provisions to offset them, the generator would operate far from satisfactorily.

In reality, the operation of incandescent lamps is the most crucial test of the regulating qualities of a generator; motors, or other devices, connected in multiple to the same wires may be unconcerned in slight variations of potential above and below normal, but when it is realized that a one per cent variation in voltage results in a variation of six per cent in the candle power of the lamps, an idea of the value of constancy in potential is formed. Again the place where the potential is to be kept constant is not at the generator, but at the lamps. Losses in transmission of currents are unavoidable, and the greater the current the greater the loss. A summation of the principles concerned then shows that whereas the addition of a load tends to reduce the potential of a simple dynamo, the conditions of the circuit demand an actual rise.

A presumably constant potential distribution of commodities other than electricity is given by ordinary gas and water systems. Such aim to maintain constant pressures at the various outlets, and that whatever the demand, there shall be no shortage in the supply. Shortcomings from such aims are, however, commonly experienced, but are far more tolerable than in the case of the supply of electricity.

The first generators of commercial size to work regularly on this class of service were made by Edison. Previous to his work, all dynamos were of the series wound field magnet variety. Although admirably adapted for series arc lighting, such winding is possible for one particular load only of incandescent lamps in multiple. Edison's early installations consisted of several generators of the same size; but one of them, a series machine, was used to excite the field magnets of the others. A variable resistance in this exciting circuit served to increase or decrease the

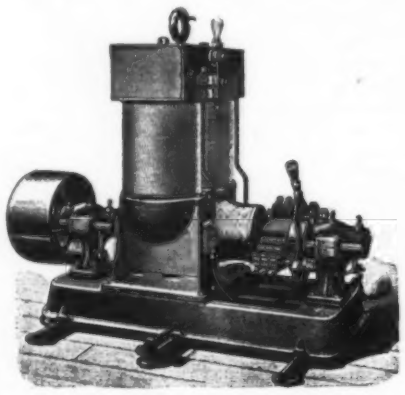


Fig. 18.—Edison Bipolar Generator for 60 Kilowatts at 125 Volts. Type of 1885.

magnetism and thereby keep the potential at the value demanded by the lamps. This method had the defect that there was no provision for adjusting the potential of each machine separately. An obvious change was to wind the field coils of the different machines with finer wire and connect them in multiple instead of in series with each other. A resistance in each generator circuit could then be varied without involving the others, while a similar one in the exciter field circuit would enable simultaneous control of all the machines. A third step was to dispense with this separate exciter, and let each field magnet derive current from the armature of its own machine. The shunt wound dynamo was not really an invention of Edison, but was a practical adaptation. In later years, shunt wound generators of even very large sizes have been made, but still following this simple method of field excitation and control. Especially in central stations in connection with storage batteries on lighting circuits, the plain shunt wound generator has valuable characteristics of reliability and constancy.

Edison employed armatures of the Siemens drum type; and in this his choice was fortuitous, for in it there is room for considerable more iron than in the Gramme ring, thereby using a low density of magnetization; also the self induction of a drum armature being only quarter that of a ring, with the same number of turns of wire, this factor, which would interfere with the ready response of the dynamo to the demands of the circuits, is made a minimum. Unfortunately, Edison copied the slender proportions of the field magnets of arc lighting machines, in fact, built them so high and slender that they soon received the epithet of "steeple" dynamos. His famous "Jumbo" machine of 1881, the largest size constructed up to that time, and the first to be directly coupled to a reciprocating steam engine, really capped the climax of bad field magnet design. After Hopkinson had applied his law of the magnetic circuit, the regular machines were redesigned, and were known in England as the "Edison-Hopkinson" dynamos, and in this country as the "1885" Edison type. The same weight of metal was used in the field cores as before, but they were made of about half the length and twice the cross section. About twice as much magnetism, with no greater expenditure of energy in the coils, was thereby obtained.

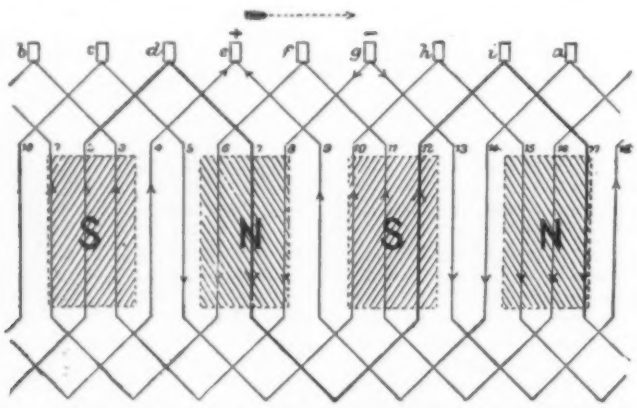



Fig. 19.—Development of Series (Wave) Wound Drum Armature for Four-pole Field Magnet.

The appearance of a standard 60-kilowatt Edison dynamo is shown in Fig. 18. To separate the cast iron pole pieces from the iron base, zinc blocks are used; this metal is non-magnetic and cheaper than any other suitable material. Wrought iron cores are within the field coils and a block of the same material joins the upper ends to complete the magnetic circuit. Rectangular bundles of straight copper wires serve as brushes on the commutator. Nearly 100 horse-power is required to operate such a machine at its full load of 1,000 16-candle-power incandescent lamps. Quite a variety of sizes of this general type were constructed by the Edison Company in Schenectady, N. Y., the smallest being of ½ kilowatt, the largest of 200 kilowatts capacity.

In Lynn the Thomson-Houston Company made machines of the same characteristics, except that the armature was placed at the top, and the wrought iron block sunken in the base. This change reduced the leakage of magnetism between the poles, and allowed greater accessibility to the armature, but the higher center of gravity required rather more careful balancing of the rotating member. The sizes were between 1½ and 90 kilowatts with 62 kilowatts as the standard. From the first, these generators were made to supply current at nearly constant potential by the automatic action of the now generally adopted "compound" field magnet winding; the initial and principal part of the field flux is obtained by the use of the shunt portion of the field coils; thereby the generator is ready for instant demands for current; in addition to this winding there is the series portion, consisting of but few turns of large wire, sufficient in size to convey the entire current. The two sets of coils are carefully insulated from each other, but so connected in circuit as to make their magnetizing effects cumulative rather than differential. The potential at no load is adjusted to any desired value by the use of the variable resistance, now called a "rheostat," in the shunt field circuit. When a load, such as lamps, motors, etc., is applied, the main current circulates also through the series coils, and if they are properly proportioned, just the right amount of magnetism will be added to that provided by the shunt current to hold the potential constant. A practical method in winding such compound spools is to put on more series coils than are really needed, and then, by means of a low resistance strip of German silver, shunt off such part of the main current as may be determined by experiment. The ability to make this adjustment is of great value in operating a number of such generators in parallel, or multiple. For satisfactory regulation it is important that compound wound generators should have soft iron field magnets of liberal section, for the series coil must produce magnetization proportioned to the current, and this condition cannot be attained unless the iron is far from saturation. It will be recognized that this is just the opposite of effective constant current operation.

Compound wound generators are of great advantage over those with plain shunt winding for railway work. In that class of service, fluctuations of load are so extreme and sudden as to be completely beyond the possibility of manual control of the potential. Still such generators have their frailties; especially is the danger to be avoided that the current from one machine shall not pass backward through the series coil of another, with which it is normally in multiple, reverse its polarity and cause interruption of the service, if not grave disaster. The "equalizing" connection, made of large copper cable, which con-

nects together all the brushes of the various machines that also represent the beginnings of the series coils, provides a usually effective safeguard. By this means, if one machine suffers a momentary diminution of potential, some of the current from the other machines will flow in the right direction through the series coil of this one, and raise its magnetism to a suitably high degree to correct the discrepancy. Likewise, if one machine experiences an undue rise in potential, its current will flow in larger measure through the series coils of the other machines, and less in its own, thereby again equalizing the potential from all. Within moderate limits the equalizer is beautifully effective, but is quite unable to cope with such extreme faults as the breaking of a shunt field circuit, or of considerably slackened speed of rotation. The use of storage batteries in connection with compound generators represents an ever present source of reversal of polarity, and for incandescent lamp loads, where the fluctuations are not sudden, many central stations have resorted to the plain shunt winding; in such a case, a reversed direction of current would merely make the armature run harmlessly as a motor without change of direction of rotation.

Brush claimed to be the inventor of the compound winding, for he had used the double coils on some early plating dynamos; however, he made the shunt the minor in place of the principal magnetizing factor. The litigation that naturally arose centered about the English patent, but Brush finally lost it. In consequence of the ownership of the Brush Company which was gradually being acquired, the Thomson-Houston Company did not hesitate to utilize the principle, but the Edison Company refused to make compound machines until the fate of the patent had been definitely determined, and the demands of railway service had become imperative.

As implied in the title, the potential of a generator of this class is independent of its size; there is not much more difficulty in insulating a large machine than a small one. Increase of output requires merely larger conductors. The bipolar design of Edison, and the like, is, however, not found economical for large sizes, and by a logical sequence, some of the features found to be good in large machines are very properly now embodied in small ones. By using multipolar field magnets and armatures of large diameter, though of short axial length, the same weight of materials allows a considerably greater electrical output at even reduced speed of rotation. For instance, the 60-kilowatt Edison bipolar generator weighed nearly 10,000 pounds and required a speed of 700 revolutions per minute, while with the more modern construction of four poles, the weight is about 7,000 pounds and the speed 550 revolutions per minute. With more poles the gain is still further possible, with the limiting factors of always having enough commutator segments between adjacent brushes to prevent sparking.

The building of large generators has become a definite art, with many ingenious and highly effective methods of procedure. Particularly has the armature construction been highly developed, and though the smooth core ring type was somewhat used years ago, it has given way to the cheaper and more effective toothed drum type.

At the bottom of all modern methods of winding large drum armatures lies Eickemeyer's invention of the "formed" coil; though applied by him for two-pole field magnets only—a special case still attended with some difficulties—it is now recognized as supplying the only practical means of utilizing multipolar fields. The particular requirements to be met are simple means of allowing enough conductors in series in a small machine and not too many in a large one to generate the same number of volts; then, too, the conductors must not be so small as to waste room with their insulation, or be so large as to prevent the necessary bending; to secure electrical and magnetic balance, coils on different parts of the armature should be of the same length and shape. All of these conditions are complied with by suitable application of Eickemeyer's principle. Coils are wound on forms of proper shape, insulated, transferred to the armature core, and connected in either of two methods. In case of a small machine for say 500 volts, these individual coils might consist of quite a number

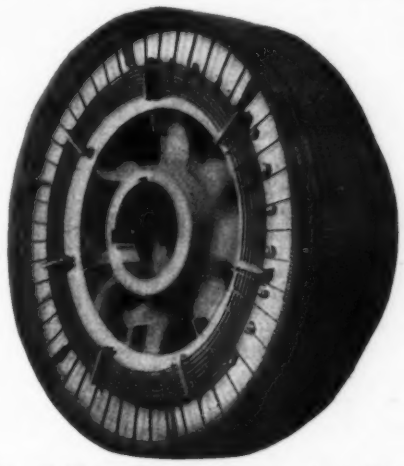


Fig. 21.—Multiple Wound Drum Armature, Showing Equalizing Connections.

of turns of small wire, but this whole voltage need not be generated by the action of one pair of poles; second and third, or still other pairs of poles, can be made to contribute their share by connecting the coils according to the "series" grouping. By this means the electro-motive force induced in the conductors under one pair of poles is added to that induced under the other pairs. The case is as if there were as many separate dynamos in series as there are pairs of poles, and it is readily seen that with a given terminal voltage, each armature would be called upon to generate only a fractional portion of the whole. Four-pole field magnets with such armature windings are the standard practice for railroad motors and for small isolated plant generators. For this particular case, it is essential that there be an odd number of coils and commutator segments, and that the terminals of any one coil connect with a certain segment, and with the one most nearly opposite. Various diagrams can be drawn to represent such connections, but a plain method consists in regarding each coil as consisting of only one turn of wire, and spread out on a flat surface, as if the armature had been rolled along and left its winding behind. In practice, two-layer windings are ordinarily employed, a given coil occupying the bottom half of one slot and the top half of another slot distant from the first by an amount equal to the polar spacing. A simple diagram representing a single layer winding with nine coils and nine commutator segments, and a four-pole field, is shown in Fig. 19. It will be observed that a given coil extends from segment *d* to *i*, and that the rest follow in exactly symmetrical order. Such a winding affords two circuits only, for by starting at any point and following the zigzag lines, one half the entire winding is traversed before again reaching the starting point. Neutral points exist in the windings midway between every two poles, but whatever their actual number, only two sets of brushes need be used. Their location in this diagram is indicated by the + and — signs; in a circular diagram they would appear in their actual locations, 90 deg. apart for a four-pole field, 60 deg. apart for six poles, etc. This property of the multipolar series wound armature to dispense with brushes at some possible positions on the commutator is especially appreciated in such inconveniently accessible machines as railroad motors. In stationary machines, where the whole commutator is visible, brushes may be used at all the neutral points, thereby saving some axial length of the commutator; in this case, alternate brushes are necessarily of the same polarity, and are connected together while the rest form a second set, of the opposite polarity. On account of the up and down movement involved in following the diagram, a third appropriate name for this winding is the "wave;" hence "series," "two-circuit," and "wave" mean the same thing.

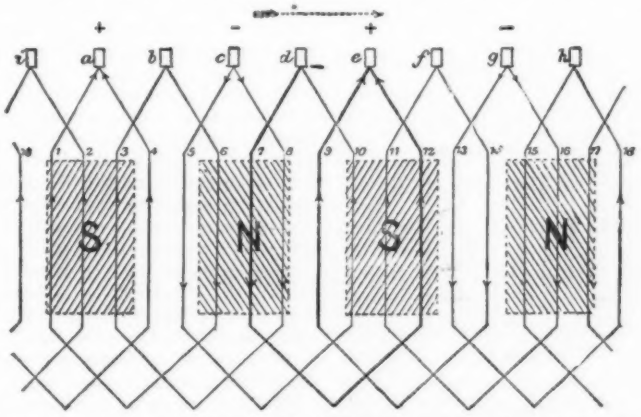



Fig. 20.—Development of Multiple (Lap) Wound Drum Armature for Four-pole Field Magnet.

Were this shape of coils, though consisting of one wire only, used for large multipolar generators, the potential would be too high, and the two circuits could not supply all the current desired. "Multiple" windings are, therefore, used with admirable success. Taking again the case of a four-pole field, a given coil, instead of connecting to opposite segments, is made to connect to adjacent ones, as to *d* and *e*, as shown in Fig. 20. It is seen also that this one coil lies under two poles in such a manner that current can flow from the positive segment *e* to the next negative one, either *c* or *g*, without involving the other two poles; therefore, to get the benefit of the rest of the winding that lies under these other poles, two additional brushes must be symmetrically placed. The diagram shows nine segments and coils as in the other case, but usually an even number would be used, divisible by the number of poles. Following through several coils, it is seen that one part of the path immediately laps on the preceding, hence the name "lap" is often given to this type—multiple, parallel, and multi-circuit being also synonyms. Very large generators of this sort for lighting service have been made, as for instance of 2,700 kilowatts in output, the field magnet having 28 poles and measuring 27 feet in diameter, and the commutator with nearly 2,000 segments, and measuring 15 feet in diameter.

In multiple wound armatures, a difficulty is often experienced in securing equally good commutation at all the brushes. Slight inequalities in the strengths of the different poles will allow slightly higher electromotive forces to be generated in some coils than in others, and thereby certain portions of the winding will do more than their share of the work. This trouble is sufficiently serious in large generators to require remedy, which is afforded by the internal equalizing connections, such as one shown in Fig. 21. A convenient or arbitrary number of points that ought to be at the same potential are compelled to comply with that condition by being connected together through a low resistance copper ring; in the figure, seven different lengths of radial connectors are seen, every seventh one connecting to the same ring. This particular armature is adapted for an eight-pole field magnet and has 432 commutator segments.

Since the series coils of compound wound fields must carry the entire current, or nearly all, their conductors must be of large section, sometimes by no means easy to wind and connect. In case of round spools, a long strip of sheet copper is often wound like a ribbon extending the whole breadth of the space, the separate convolutions being insulated by a strip of thick paper wound in at the same time. Terminals are made of several layers of thinner sheet metal riveted and soldered crosswise at the ends of the ribbon and then bent up at a right angle along the spool flange. Insulation is then placed on this portion of the winding, and the shunt wire wound on top. Another method is to use a narrower and thicker ribbon, and allow the series coil to occupy the full radial depth, with the shunt coil alongside. If square field coils are used, as must be the case with laminated cores, a bare copper bar bent edgewise at the corners is sometimes used, notably by the Westinghouse Company, an operation demanding special and heavy tools. Insulation is placed between the adjacent surfaces of the coils only, and then the whole is bound together in various places by strong twine, leaving a part of the edge of the copper exposed to the air for the better radiation of

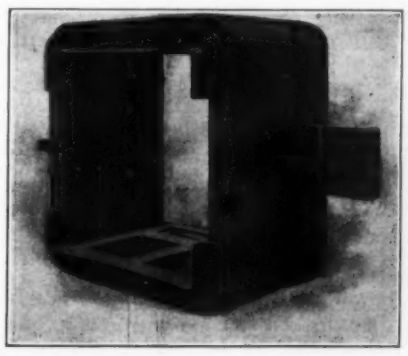


Fig. 22.—Series and Shunt Portions of Field Coils for Over-Compounded Railway Generator.

the inevitable heat. The series coil ordinarily occupies about one half or one third as much space as the shunt. Their relative sizes, together with their respective terminals and twine binding, is shown in Fig. 22.

Aside from the massive size of field magnets of constant potential generators, the armatures, too, are required to be of very rugged construction, in order to withstand the severe stresses due, not alone to the regular load, but to continued overloads or even momentary short circuits. With the possible exception of the screw propellers of large steamers, no other machinery represents so much expenditure or transformation of energy in a given space. Though the amount of the torque that exists between the magnetism of the field and the currents in the armature conductors is exactly computable, some apparently inscrutable mystery still attends the conception of the real physical forces that are at work. The armature conductors nowhere touch the field, yet the powerful engine, or other prime mover, may often be unequal to the struggle of maintaining the motion against the invisible reaction.

One highly important detail that has largely contributed to the successful operation of constant potential machines has been the employment of carbon brushes on the commutators. Originally proposed by Van de Poele, a pioneer in railroad engineering, and suffering temporary banishment on account of insufficient size of commutators, their use is now practically universal.

Aside from minimizing the wear, this material represents an elegant application of a little electrical resistance at just the right time. With the variations in load there is an unavoidable shifting of the neutral point where the brushes should be placed; were copper brushes employed, they would at times be bridging across segments between which slight differences of potential existed; the coil connecting any two segments may have a very low resistance, and therefore a local current may flow through it and the brush of really larger magnitude than the main current. The rupture of this short circuit current, as the commutator moves on, results in heat and sparks that seriously impair the commutator surface. Due regard for this expensive member of a dynamo demands preservative methods, and these are found in carbon brushes. They have a low enough resistance to transmit the main current without serious loss, and yet high enough resistance almost entirely to suppress the harmful short circuit current of the coil that is undergoing commutation. For good results, not more than five per cent of the segments should be in contact with brushes, and these latter be in sufficient number to give considerable independence of movement, and not to convey more than 40 amperes per square inch of contact. Often the commutator of a large generator is nearly as large and quite as expensive as the armature itself.

On account of the low degree of magnetization of the iron, and low resistance of the armature windings of constant potential generators, they can readily be made of high efficiencies, often approaching 95 per cent. This qualification, added to the feasibility of being constructed in large sizes, has been a potent factor in the exclusiveness with which they are occupying the field of engineering.

This article has considered machines of the direct current sort only; alternators usually belong to the constant potential class, but an explanation of their construction will form matter for a subsequent article. The next will be on "Incandescent Lamps," representing a class of service which first demanded the constant potential dynamos.

(To be continued.)

# THE TREND OF STORAGE BATTERY DEVELOPMENT.*

## BY L. H. FLANDERS.

IN considering the development of storage batteries, two questions naturally arise: Why are lead plates with sulphuric acid the prevailing types of battery? Why does not development manifest itself along new lines using metals of higher capacity per unit of weight than lead? Experience and the present status of electro-chemistry indicate that there is very little probability of securing successful storage batteries unless the following conditions be met: First—That the metals and their salts which compose the plates be insoluble in the electrolyte. Second—That when the plates are completely charged no decomposition of the electrolyte takes place with the exception of the breaking up of the water into hydrogen and oxygen.

It is true that other metals have been tried which dissolve on discharge and are redeposited on charge, but such plates have never been successful on account of the difficulty of controlling the metallic deposit. These two principles immediately narrow the choice of electrolyte to caustic potash or soda, and sulphuric acid. The first two have the disadvantage that they carbonate on exposure to the air. Furthermore, the alkaline electrolyte is only usable with cells of the so-called "oxygen lift" type such as the Edison battery. This type of cell has not reached commercial importance and, on account of the high cost of materials, the relatively low efficiency and the mechanical difficulties encountered in its manufacture, will probably have a very limited application, principally to electric vehicle propulsion.

In regard to the plates, lead is the only available metal which is insoluble in sulphuric acid, and this, coupled with the fact that lead peroxide and lead sulphate are also insoluble, accounts for the general use of the lead-sulphuric acid type of storage battery. Another cause tending to the further use of lead is that, next to iron, it is the cheapest available metal in the arts.

The development of the lead-sulphuric acid type of storage battery has been along two distinct lines: First—Batteries intended mainly for stationary service. Second—Batteries for vehicle propulsion.

Where storage batteries are to meet the first condition, life and efficiency are the chief considerations and energy capacity per unit weight is not a deciding factor, while with the storage battery intended for vehicle propulsion, energy capacity per unit weight is the controlling element. Long life and energy capacity per unit weight are directly opposed to each other. In designing plates for stationary service, such a compromise must be made that the annual charge for the perpetual maintenance of the battery will be a minimum. This annual charge is made up of the interest on the investment and the maintenance expense for labor and material. By way of illustration: if a plate having too large a percentage of active material to total weight be used, the energy capacity per unit weight will be high, the first cost for a given capacity of battery will be low together with the interest on the investment, but the labor expense for maintenance, together with the cost of renewals, will be so high as to make the total annual charge prohibitive. On the other hand, if the energy capacity per unit weight is too low, the first cost and consequently the interest charges on the investment will more than offset the reduced annual maintenance expense.

In this article storage batteries designed for stationary use only will be considered, and the discussion of such an installation will be given in the following order: First—Plates. Second—Electrolyte. Third—Containers. Fourth—Material for installation. Fifth—Auxiliary electrical apparatus. Sixth—Care and operation.

For the sake of clearness let it be understood that theoretically at the beginning of the discharge of a charged cell the elements consist of positive and negative plates in a solution of sulphuric acid. The positive active material is peroxide of lead which surrounds a supporting conductor. The negative element consists of spongy lead supported by a conductor. The sulphuric acid permeates the pores of the active material of the plates. During discharge the active material of the plates contains an increasing amount of lead sulphate and the electrolyte contains a decreasing percentage of sulphuric acid. At the end of the discharge the active material of both plates has been reduced to sulphate of lead and the electrolyte has been changed to water. The oxygen of the positive plate has combined with the hydrogen of the sulphuric acid to form this water, the sulphate having combined with the lead of the active material. Thus both plates are lead sulphate and the cell is at zero potential. Upon charging, the reverse action takes place. The water in the solution is replaced by sulphuric acid formed from the sulphate liberated by the plates and hydrogen from the water, the oxygen of the water uniting with the lead of the positive plates. Theoretically, the battery is in the same condition after a discharge and recharge that it was at the beginning of the discharge. From the foregoing, it might be inferred that the storage battery has no depreciation, but, unfortunately, such is not the case.

Positive lead plates are of two types, the Planté and the Faure. The Faure or pasted type is not used as a positive plate for stationary service in this country. While it is of high capacity per unit weight, the active material, which is in relatively large masses, softens and disintegrates more easily than the active material of the Planté type, which is formed from the grid itself, and is in thin layers surrounding a conductor and accessible to the electrolyte. In the pasted construction, large masses of isolated sulphate may form which are inaccessible to the current and electrolyte, so that great difficulty is experienced in keeping these plates in condition, and, unless properly handled, they are liable to disintegrate rapidly. The one disadvantage in the use of pure lead Planté positive plates is the growth or expansion of the peroxide which stretches the pure lead frame to which it is attached. This feature has led to the modified form of Planté plate, in which the active portions are of pure lead surrounded by a containing frame of antimony lead. This hard frame will not distort and thus the growth of the pure lead pellets is restrained. In some plates, the active portions, in the form of biscuits two or three inches square, are attached to one side of the lead antimony frame, with open spaces between the biscuits and the other three sides of the frame to allow for their growth. In one type of plate the biscuits are attached at the two opposite sides of the antimony frame and are left free to expand at their ends. A grooved lead plate with a Planté formation will grow in length, that is, in the direction of the grooves rather than transversely. Aside from the disadvantage of buckling or warping, which is liable to produce short-circuits between the adjacent plates, the integral pure lead plate possesses decided advantages over the composite type of Planté plate. The futility of attempting to prevent the growth of the active portions of the plate has been recognized, and, therefore, provision has been made for this growth so that it will take place within the confines of the plate itself. The buckling effect is thus confined to the individual section and does not develop in the plate as a whole. Such a plate is of one piece of pure lead without joint or weld and, as a consequence, has a very low internal resistance. It is so constructed that all over the plate, the current and the electrolyte are equally accessible to the active material. It should be stated that the plate is divided into thirty-six active portions consisting of longitudinal laminations surrounding the surface of which is a thin layer of peroxide of lead. Between these biscuits and connecting them, is a corrugated sheet. As the plate grows, the sections extend in length, thus closing up the corrugated expansion joints, but taking up the growth within the plate itself.

The pasted type of negative plate is largely used, but possesses the disadvantage of requiring careful handling. On the other hand, the ordinary form of Planté negative is exceedingly durable and will stand all sorts of abuse without mechanical disintegration. It will not, however, maintain its capacity, which drops in a few hundred discharges to from 50 to 25 per cent of its initial value. The capacity may be temporarily restored by charging the negative to positive and back again to negative, or completely reversing it. This loss of capacity tends to prevent the adoption of this form of Planté negative plate. This loss may be explained by the shrinkage of the negative material caused by the cohesion of the pure lead walls of the spongy lead mass constituting the active material. This will be appreciated when it is explained that the negative active material, when fully charged, is lead of the utmost purity and that any oxidation is prevented by the bath of nascent hydrogen given off when the plate is charged, and that clean surfaces of lead may be united by simple pressure. Due to the contraction and expansion of charging and discharging, the thin walls of some of the pores throughout the active mass collapse and stick together, thus reducing the porosity and consequently the capacity of the plate.

In a Planté negative plate lately developed inert material has been introduced into the pores of the spongy mass, which has evidently prevented the collapsing and sticking together of the walls of the porous material, since the plates have a sustained capacity for an apparently indefinite time. Since there is no corrosion and disintegration in the Planté negative plates, the lead conductors and supports are made lighter than in the positive plates and no provision is made for expansion.

There is little probability of any development being made in the electrolyte beyond increasing and maintaining its purity.

The most durable form of containers for stationary batteries are glass jars and tanks, but these are limited in size and are also liable to breakage during installation when of large size. Lead-lined wooden tanks are used for elements that are too large for mounting in glass jars. These are very satisfactory, provided the wooden parts of the tank are kept clean

* Abstracted from the Electric Journal.

and frequently painted. Efforts are being made to manufacture glazed earthenware tanks. If successful, these will prove absolutely permanent, and, while their first cost will probably be somewhat higher than lead-lined wooden tanks, the reduced maintenance charge will more than compensate for this increase.

Too much care cannot be taken in seeing that the batteries are properly installed, as proper installation is a large factor in reducing the maintenance expense. The plates should be adequately separated from each other. A new form of plate support is grooved glass, the edges of the battery plates being held in vertical grooves in these glass plates. In this way the plates are kept uniformly spaced and short-circuits around the plates are prevented.

Great care should be taken to secure proper insulation of the battery cells from each other and from the ground. The heating and ventilating of the battery room is also of great importance. The available normal capacity of the battery, at the eight-hour rate of discharge, is reduced 0.56 per cent for each degree F. drop in the temperature below the normal 70 deg.

When the surface of the tanks becomes coated with a film of sulphuric acid, this surface never dries, and the film must be removed by neutralizing with caustic soda. This action is explained by the fact that sulphuric acid, beyond a certain density, is hygroscopic and therefore will absorb water from the air. By using the exhaust system of ventilation, the sulphuric acid spray given off by gassing may be withdrawn so that it will not precipitate, while if a blower is used, eddies of air will deposit the spray in a thin film over everything in the room.

In order to secure the maximum value from a storage battery installation, the electrical auxiliary apparatus in the way of boosters, switchboards, etc., must be of ample capacity. Attempts to overwork the auxiliary equipment on overload is "penny wise and pound foolish," as this part of the equipment, while it approximates only from 10 to 25 per cent of the total cost of the installation, is absolutely essential to its successful operation.

A storage battery requires periodic, but not excessive, care to secure the best results. Unlike engines, generators, and motors, the storage battery, when abused, gives no audible and seldom any visible signs that it is not working properly, but continues to deliver current until it may be severely injured.

By using the specific gravity method of charging, that is, charging until the specific gravity of the electrolyte returns to the original value that it had at the beginning of the discharge, the efficiency and life of a battery may be much greater than when methods depending upon the voltage only are used. The specific gravity method is based on the fact that for each ampere-hour discharge, a definite amount of sulphuric acid is transferred from the electrolyte to the plates in the form of sulphate. Conversely, this sulphate is returned to the solution on charging. The change of specific gravity of the electrolyte is independent of the rate of discharge, so that knowing the change in specific gravity of the electrolyte for a normal discharge of the battery, the energy taken out at a varying rate of discharge can be determined at any time.

The persistent use of the auxiliary cadmium electrode to determine whether trouble is caused by the positive or negative plates should be encouraged. The use of distilled water for replenishing the loss in the solution due to evaporation and care in preventing impurities from getting into the cells should be insisted upon.

The storage battery, as now installed, is one of the most reliable pieces of apparatus available for the electrical engineer. The life of the negative plates is now indeterminate. The positive plates last from four to eight years, depending upon the service. Storage battery manufacturers make it a practice to enter into maintenance contracts with their customers, guaranteeing that the maintenance cost will not exceed 7 to 10 per cent of the cost of the battery for a period of ten years. Unlike other machinery, at the end of ten years, the installation will have the advantage of the latest developments in the art since, in renewing the plates, the latest types can be used. It is worthy of note that several millions of dollars have been invested in storage batteries by the prominent illuminating companies, these batteries being used simply for insurance against shut-down. They are only discharged when there is something wrong with the regular supply. At all other times they are kept fully charged and floating on the system. This shows the reliability and value of the storage battery of the present day in large power plants.

# THE ATOMIC WEIGHT OF RADIUM.*

## A NEW DETERMINATION

### BY MME. CURIE

THE determination of the atomic weight of radium which I published in 1902 (Comptes Rendus, July, 1902) was carried out with 9 centigrammes of radium chloride. Fresh processes having since then furnished some decigrammes of practically pure chloride, I have subjected them to purification, which enabled me to obtain 4 decigrammes of perfectly pure radium chloride, and to determine the atomic weight of radium under far better conditions than before.

The purification processes consisted as before in fractional crystallization in water containing hydrochloric acid, or in fractional precipitation of the aqueous solution by alcohol. The progress of the fractionation was controlled by photographs of the spark spectra, obtained with the spectrograph which formerly belonged to Demarçay. It is convenient to compare the relative values of the lines 4554.4 of barium and 4533.5 of radium. These lines, which are very close together, are very suitable for comparison. The line 4554.4 is the strongest in the barium spectrum, and the line 4533.5 is one of medium importance in the radium spectrum.

When the purification was stopped, the strongest barium line was still faintly visible near the other. Its complete elimination seemed to be very difficult with the quantity of material I had at my disposal. Nevertheless, I shall shortly show that the salt was very pure.

I was confronted with one difficulty during this work. When a clear solution of a radium salt is evaporated in a dish or glass, the dry salt obtained is not generally completely soluble in water, but leaves a residue. I have found that this residue is partly due to the formation of radium sulphate, in consequence of the presence of traces of sulphuric acid in the reagents (traces which could only be detected by barium salts after the concentration of the reagents), and partly to the slow action of the radium salts on the vessels. I therefore decided to prepare specially all the reagents employed. The water was distilled in a platinum still, and received and kept in a platinum flask: this water was used to prepare the hydrochloric acid, which was also kept in a platinum flask. The nitric acid, alcohol, and silver nitrate were also purified. It is not possible to let the radium chloride crystallize in presence of hydrochloric acid in a platinum dish, because it has considerable action on the latter. But if the clear solution is allowed to crystallize rapidly in a porcelain dish, crystals are obtained, which, after being dried, dissolve in the purified water without residue, and hence can be used to determine the atomic weight.

The method employed for this determination was the same as before. It consists in estimating as silver chloride the chlorine contained in a known weight of anhydrous radium chloride. According to my earlier eperiments, which were confirmed by new observations, radium chloride, which has just been prepared, loses its water of crystallization when it is heated in a drying oven above 100 deg. C., and its weight is quite constant when it has been subjected for half an hour to a temperature of 150 deg. C.

The weighings were performed with a Curie's aperiodic balance with direct reading for weights below decigrammes. This rapid balance is accurate to one-tenth of a milligramme, and takes only ten seconds to reach its position of equilibrium. The weighing of the radium chloride is more difficult than that of the silver chloride, because the former salt absorbs water-vapor rather quickly; it is therefore essential to let it cool in a desiccator with phosphoric anhydride before weighing, and not to recommence weighing until after it has been again placed in the drying oven, even if the cage of the balance contains desiccating substances.

After each estimation the radium is present as nitrate with silver nitrate. The silver is eliminated by hydrochloric acid, and the nitric acid by repeated crystallization in presence of hydrochloric acid.

The following table gives the numbers obtained in three consecutive experiments, and the atomic weights P deduced from them, assuming that radium is a divalent metal, and that the atomic weights of silver and chlorine are:

Ag = 107.8, Cl = 35.4.

| Radium Chloride. | Silver Chloride. | P. |
|---|---|---|
| 0.4052 | 0.3906—0.00006 | 226.35 |
| 0.4020 | 0.3879—0.00006 | 226.04 |
| 0.39335 | 0.3795—0.00006 | 226.15 |

Weight of filter ash = 0.00006.

The weighings of the two chlorides are considered to be exact to about one-tenth milligramme. These three experiments, which agree very closely, give for the atomic weight of radium the mean value 226.18.

The experiments, performed in 1902 with very pure radium chloride, gave less concordant results and a mean of 225. The spectrum of the salt used recently shows a rather greater degree of purity, but the difference of about one unit in the atomic weight could not be ascribed to this cause. I performed a control experiment as follows: I prepared a solution of some milligrammes of pure 1907 salt, and added to it a small quantity of a titrated solution of barium chloride. The amount of barium salt in the mixture was 0.61 per cent. In the spectrum of this salt a great increase of the intensity of the barium spectrum is shown, whereas the change of atomic weight, calculated from the known addition of barium chloride, is only 0.7 unit. From the examination of the spectra it is clear that the difference between the numbers obtained in 1902 and in 1907 should be attributed only to the inferior accuracy of the experiments performed with only 9 centigrammes of radium salt and with less pure reagents.

The above experiment also proves that the spectral reaction of barium in presence of radium is very sensitive and that the radium chloride which was used for the determination must be very pure. It certainly does not contain 0.1 per cent of barium chloride.

I therefore conclude from these experiments that the atomic weight of radium is 226.2 (Ag = 107.8, Cl = 35.4) with a probable error of less than half a unit.

If the values Ag = 107.93, Cl = 35.45 are adopted, the value is Ra = 226.45.

* Comptes Rendus, 1907.

## HELION FILAMENTS.*

By WALTER G. CLARK.

THE helion filament is a composite filament in which the base used is a very small carbon filament. It is possible to use other bases, but carbon seems best suited to the requirements. The small carbon base is mounted in a treating jar very similar to the one ordinarily used in treating or flashing the carbon filament. In this treating flask a compound containing silicon is deposited upon the filament. For this purpose has been developed apparatus which is very nearly as automatic as the method used in flashing the carbon filament. The material deposited is, apparently, at first carried into the carbon, but as the process is carried further the filament takes on a surface deposit. As soon as this occurs the emissivity increases very greatly, and the color of the light changes from the characteristic color of a carbon filament to a much whiter light, and this with practically no change in temperature.

The filament is built up with this deposit until the desired resistance is reached, when the current is cut off. The filament is then ready to be mounted in the ordinary glassware as used for a carbon filament. The resistance of the helion filament is sufficiently high to utilize 110 volts in a single corrugated loop, and the filament has sufficient mechanical strength so that it is practically impossible to break it without breaking the glass inclosing the lamp.

The filament may be burned in any position, and in some recent tests a temperature of 3,300 deg. C. was reached before the filament showed any very decided tendency to sag or soften.

It has been found that the helion filament possesses a negative temperature coefficient up to about 1,350 deg. C., at which temperature the coefficient becomes positive, and from there on the filament exhibits a decidedly positive temperature characteristic; so in the helion filament occurs the negative temperature coefficient at starting, and the desirable positive temperature coefficient at the temperature at which the filament is to operate. Another feature possessed by the lamp is that the decrease in candle-power appears to be very slight; experience indicates that the lamp would operate up to a point where the filament parts, with a reduction in efficiency of less than 5 per cent.

The filament, on account of its positive temperature coefficient when incandescent, withstands an overload remarkably well, and an excessive voltage usually destroys the leading-in wires or the glass in the stem of the lamp without damaging the filament.

That the lamp is able to operate at an efficiency of better than 1 watt per candle-power in the larger sized lamps is indicated by the fact that a lamp of 400 candle-power at 300 watts burned for about 300 hours in a very imperfect vacuum, after which the filament was taken down and examined; but apart from the oxidation due to the air present when the lamp was started, there was practically no change.

* Condensed from the Electrical Review.

# BRIDGE BETWEEN DUISBURG AND HOMBERG.

## A NEW STRUCTURE ACROSS THE RHINE.

MOST American readers will be surprised to learn that the most important inland port in Europe is Duisburg-Ruhrort, situated at the confluence of the Rhine and the Ruhr, opposite the health and pleasure resort Homberg, in Rhenish Prussia, not far from Düsseldorf.

Forty thousand vessels, with cargoes aggregating thirteen million tons, annually load and discharge at Duisburg. This lively commerce has made necessary the construction of the bridge herewith illustrated which, though built for utilitarian ends, forms an impressive ornament to the landscape. The traffic between the commercial city and the spa has hitherto been confined to railway and other ferries, which were always very inconvenient and unreliable and were often stopped entirely by ice and fog. The remarkably rapid growth of the towns on the left bank of the Rhine, in consequence of the development of the extensive coal mines of Rhenish Prussia, made a permanent connection between the two shores of the river an imperative necessity.

The floor of the new bridge is nearly level, with a gentle upward grade from each end toward the middle. The bridge is supported by four piers in the river in addition to the abutments on the banks, and is composed of two cantilevers and three suspended trusses. The length of the middle span, the longest of the five, is 667 feet. It is made up of a 112-foot arm of each cantilever and a truss, 443 feet long, suspended from the ends of those arms. The cantilevers cover the intermediate spans of 399 feet between the first and second piers and 421 feet between the third and fourth piers and their shoreward arms extend 55 feet over the shore spans of 292 feet and 274 feet, the remaining portions of each shore span being covered by a truss resting on the cantilever arm and the shore abutment. The total length of the bridge between the abutments is 2,053 feet, and its total width is 54 feet. A roadway, 31 feet wide and accommodating four vehicles abreast, occupies the space between the trusses, and a footway, 6½ feet wide, runs outside the trusses on each side.

The massive towers, of which there are two at each end of the bridge, form an effective contrast to the light and graceful structure of the bridge itself. The two towers on the Duisburg shore, which are 100 feet high, are connected by a semicircular colonnade with each other and with the bridge entrance and keeper's lodge between and in front of them. The south tower contains a restaurant. An inclined avenue on each side and a broad flight of steps in the middle lead up to the elevated plaza of the bridge.

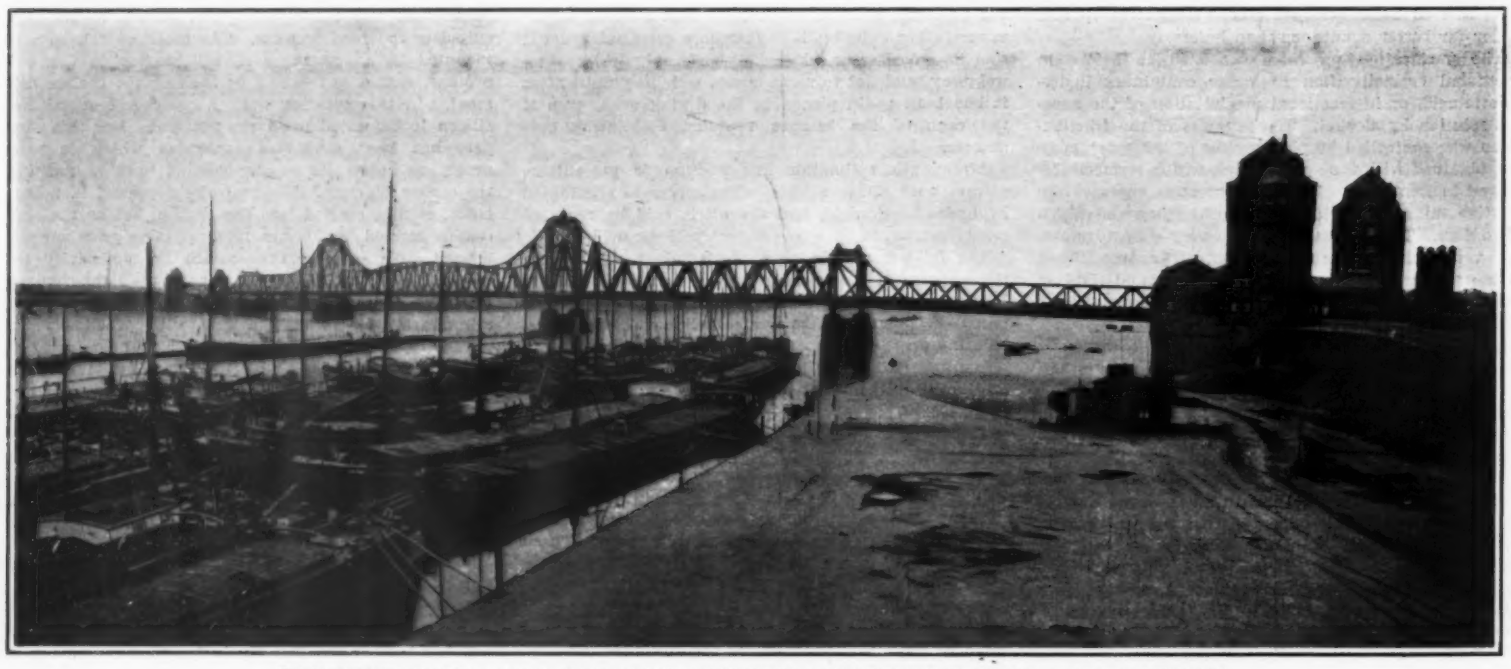
The work of construction was commenced in the latter part of 1904. In order to avoid interference with the river traffic only one obstruction of small area—a skeleton temporary pier—was permitted to be placed in the middle span and no false work whatever was allowed in the span next to it on the right.

The successful construction of these two long spans under such conditions is a notable triumph of German bridge building. The total cost of the bridge, which was borne by the towns of Duisburg and Homberg, was more than five million marks ($1,190,000).

That the expense was justified is proved by the fact that it is already proposed to erect a second bridge for railway traffic. At present, railway passengers and baggage are forwarded by the electric railway that crosses the bridge recently completed.—Illustrirte Zeitung.

THE DUISBURG TOWERS

ROADWAY OF THE DUISBURG BRIDGE.



THE NEW BRIDGE OVER THE RHINE BETWEEN DUISBURG-RUHRORT AND HOMBERG.

## THE CRACKING OF ALUMINIUM CASTINGS.

UNDOUBTEDLY, the most frequent source of the cracking of aluminium castings is overheating or "burning" the aluminium while melted. The demand for these castings has now become so large, and many of them, such as automobile crank cases and similar work, are so thin and complicated, that founders constantly have trouble in making them. They all purchase their aluminium from the same concern, and there is no reason to doubt that it is not uniform in composition and of good quality, so when a difficulty does occur, the cause may be laid at the door of the founder.

The aluminium alloy most generally used for casting is one which contains aluminium and zinc (occasionally with copper). The presence of the zinc renders the casting difficult and far more liable to crack than when not used. To obtain the highest strength, however, it must be employed.

The usual method employed by the brass founder is to set the crucible in the furnace without any coal around it. The heat of the fire bed melts it. He usually has some finishing touches to put on the mold which may take longer than he anticipates, or he may have had a "drop" in lifting off the cope. At any rate it is a matter of common occurrence to find that the aluminium remains in the fire for a long time after it has actually melted. Gas is absorbed in large quantities, and much oxidation takes place. The "heat" of the aluminium is such that it must be cooled down with gates. If the casting that is to be made is a difficult one and thin, it is safe to say that it will probably crack.

There are several rules that must be firmly obeyed in making aluminium castings, and they are, to melt the aluminium with a slow fire so that the top of the metal will not become "burnt" before the remainder of the metal is melted, to avoid overheating the metal after it has once melted, and pack the ingots in the crucible as compactly as possible so that portions will not stick up and become exposed to the action of the flame. And last, but not least, is one which should be posted so that it actually becomes a rule of the shop. *Do not have the aluminium melted before the mold is ready.* This is one of the most common sources of trouble.—The Brass World.

# FIRE BOAT PROTECTION.*

## CONSIDERED FROM THE VIEWPOINT OF THE FIREMAN AND THE ENGINEER.

BY EDWARD F. CROKER, CHIEF OF NEW YORK FIRE DEPARTMENT.

TO DESIGN a boat that can be maneuvered in narrow and crowded slips, basins, and channels, it is necessary to lay down some general rules of construction. First, the boat should be twin screw, and her engines of the compound type. In this connection it should be said that for this purpose single expansion engines are not reliable; they are unsuited for maneuvering, are less efficient, and should be eliminated at the start.

The triple expansion engine is likewise not adapted for fire boat use, as it takes some time to warm up the low pressure cylinder. With the compound engine this disadvantage is avoided, and the steam is in better condition as it enters the low pressure cylinder; in consequence the boat can be started more quickly, and it is possible to make better time to a point within three miles of the station from which the boat is started.

If the turbine could be reversed as quickly and certainly as the reciprocating engine I would favor it; but in this regard many things still remain to be demonstrated with this otherwise excellent prime mover. We cannot afford to experiment in the fire service, and while the turbine is a splendid engine to drive the pumps, for the present at least, I recommend that the reciprocating engine be used as a propelling agent for the boat, and the turbine to operate the fire pumps.

The fire boat that I would recommend, should be 120 feet in length over all, with a 24-foot beam and a 9-foot draft; she should be built of steel. Frames spaced 20 inches, center to center, except forward, where for 18 feet on each bow they should be 12 inches apart, center to center. This feature is necessary to strengthen the boat for forcing her through heavy ice, and against obstructions.

The decks should be flush fore and aft, and as clear as possible of all obstructions as the boat must be ready for action at all times. The common practice of providing a large pilot house should be avoided. The edges of the pilot house should be rounded so the couplings of the hose will not catch; a small skylight between the pilot house and the tower can be provided to ventilate the engine room. A boiler hatch is necessary for the same purpose; this, with the tower, which can be used as a staff for running lights, and the turrets and hose reels, are about all that is located on deck. The turrets stand directly over the pumps. Their features will be described at length in conjunction with the fire pumps, and the water circuit.

The boat should be protected by means of proper guards; there are times at a fire when it is necessary to force the vessel into crowded slips. That she may sustain as little damage as possible, the guards and rails should be strongly built of sound well seasoned white oak.

Deficient steaming capacity has been the weak spot of nearly all fire boats. There is to-day no boat in the fire service that can run her pumps and auxiliaries to their full capacity and also furnish steam for the operation of the main engine, and it is absolutely necessary to operate the latter, as the boat must be under full control at all times.

I shall endeavor to suggest a set of boilers which will run the fire pumps, auxiliaries, and have sufficient steam horse-power in reserve to operate the main engine for maneuvering purposes, or slow towing, if necessary. The boilers should be of the water tube type with large straight tubes, a grate surface of 120 square feet, a heating surface of 4,500 square feet, and with a working pressure of 225 pounds, under forced draft; either a closed ash pit, or an air tight fire room should be employed. Such boilers would evaporate 24,000 pounds of water on an estimated consumption of 25 pounds of coal per square foot of grate surface; that is, $120 \times 25 \times 8 = 24{,}000$.

The turbine pump would consume 17 to 17½ pounds of water per B. H. P. hour, and to throw 8,000 gallons of water per minute at 150 pounds pressure, it would require approximately 1,000 horse-power. Consequently the total steam consumption for the entire pumping main or propelling engines would be, main engine 150 horse-power at 20 pounds per B. H. P. = 3,000.

Auxiliaries, estimated, 75 horse-power at 40 pounds per B. H. P. = 3,000.

Fire pumps, 1,000 horse-power at 17½ pounds per B. H. P. = 17,500.

Total 23,500.

WHEN THE FIRE IS SOME DISTANCE FROM THE WATER FRONT A HOSE IS LANDED AND CARRIED TO THE SPOT. CHIEF CROKER IS THE COMMANDING OFFICER IN THE PICTURE.

### FIRE BOAT PROTECTION.

This is a conservative estimate of the necessary steaming capacity, and as the boilers can easily supply 24,000 pounds of steam there is a comfortable margin of safety. I prefer to install the boilers fore and aft; there would not be room in a boat with 24 foot beam to place them athwartship. Furthermore I am opposed on principle to the latter arrangement of the boilers, as it is difficult to get around to clean, and otherwise take proper care of them.

The coal and water supply for the boilers must be ample for all purposes. The bunker capacity should be at least 35 tons, with a fore and aft arrangement of the bunkers. This is preferable to an athwartship arrangement, as the boat is far less difficult to trim than with the latter. In sea coast cities it is necessary to provide fresh water tanks for obvious reasons, while in cities on the Great Lakes such is not the case. There the feed water for the boilers can be pumped directly from the lake or river in which the boat operates. I am seriously opposed to the use of the built-in tank, and prefer the utilization of the vessel's sides and bottom directly as part of the tank

* Abstracted from an address before the International Association of Fire Engineers, Washington, D. C.

wall, owing to the greater difficulty in cleaning and repairing the built-in tank.

The main engine, as I have already stated, should comprise two units of the compound type with the high pressure cylinder 11 inches in diameter, the low pressure 24 inches, and the stroke of the piston 18 inches, with a maximum steam pressure of 160 pounds, and at 200 revolutions per minute each unit would develop 275 horse-power, giving a total horse-power of 550. This should be sufficient to drive the boat at a speed of 16 miles per hour if the hull is properly designed.

The auxiliaries would include the air pumps with vertical twin cylinders, two double acting 12 inch water cylinders with a 12-inch stroke, and two feed pumps with steam cylinders 7½ inches diameter, water cylinders 4½ inches, and stroke 10 inches.

Circulating pumps should be of the centrifugal type driven by independent engines, and should have a capacity of 2,000 gallons per minute. There should be a condenser of cylindrical shape with brass tubes and sheets, and having a cooling surface of 2,800 square feet.

I wish to emphasize that the practice of employing galvanized iron pipe for the auxiliaries, or for other purposes, while saving in the first cost, in the end is much dearer than suitable brass pipe; it will last but a short time in salt water, and the cost of the necessary repairs in five years would be far greater than the additional cost of brass pipe. Besides the loss entailed by the absence of the boat during the time that she is out of service for these repairs cannot be estimated; a fire-boat should be kept in service as many days of the year as possible.

On the Great Lakes this stricture regarding the piping would not apply with such force; iron pipe can be used very well in fresh water.

An efficient winding, steam steering engine should be located in the engine room so that it can be under the direct supervision of the engineers; the connection with the steering wheel in the pilot house should be by steel shafts, and cut bronze miter gears. The cylinder of the steering engine should be 4½ x 4½ inches. The hand steering wheels are preferably to be of mahogany with brass hubs and mountings; steering columns are to be of brass with rudder, indicator, and warning gongs.

In addition to the steering wheel in the pilot house there should be a second wheel abaft the water tower on the deck, together with proper signal bell pulls; this secondary arrangement is to enable the pilot to work the boat from both ends, fore and aft. This would be quite an aid in working out of crowded slips in strong tides, or currents. In addition a small steam capstan can be placed on the forward deck.

There should be an electric lighting plant, to operate about 75 16-candle-power lamps, and also a searchlight. This would require a generator of about 10 kilowatts output.

The subject that is of the greatest interest to firemen is the question of fire pumps, their style, and capacity; needless to say the success of the boat is largely dependent upon them. There are in the fire service several boats with reciprocating pumps; they have done, and are doing good work; but as already stated it is almost impossible to obtain boilers able to supply sufficient steam to operate reciprocating pumps at their full capacity. Pumps having a normal discharge of say 10,000 gallons per minute, based on predetermined piston speed, will seldom deliver more than two-thirds of the rated quantity under working conditions, because the boilers cannot supply steam sufficient to produce this piston speed, and because of the slip which increases directly as the speed increases. There is also the question of frequent repairs after every working period of any duration. In this connection it may be said that the valves require considerable attention, as the pins on the back of the suction valves corrode quickly in harbors full of sewage, and allow the valves to drop off.

Centrifugal pumps when turbine driven will do the same work with half the steam required by reciprocating units; this will enable the boat to maneuver, and run her battery to the full capacity, a condition which I believe does not exist on any fire boat in service at the present time. I therefore recommend that centrifugal pumps having a capacity of 8,000 gallons of salt water per minute be installed, that they be driven by turbine engines of the impulse type, at a speed of 1,800 revolutions per minute.

The pumps should comprise two units, each unit including a two-stage, direct-connected turbine. Four thousand gallons of water per minute at a pressure of 150 pounds to the square inch would be delivered by each unit, when supplied with sufficient steam, and when exhausting into a condenser having a vacuum equal to 26 inches of mercury. The turbine should be of the horizontal type, equipped with two bearings, and a coupling, with the pumps coupled direct to the shaft, and operated at the same speed as the turbine without the intervention of any form of gearing.

Each of the fire pumps should have a 14-inch sea suction pipe; the outlets should be provided with sea chests having composition valves and glands, Tobin bronze stems, and wheels operated from the working platform; the strainers should be fitted to the boat's side, and each should have an area 2½ times that of the opening in the valve. They are best placed just over the turn of the bilge, far enough from the bottom to avoid mud in shallow water, and far enough below the water line to avoid debris. The discharge pipes from each pump should be 14 inches in diameter, and should unite in a 16-inch main above the pumps; each discharge into the main to be controlled by a valve. A valve should also be located in the main between the two pumps. The pumps to be so arranged that one can discharge into the other, thereby rendering them the equivalent of a four-stage pump, when extra heavy pressure is required.

On the deck, above the pumps, should be mounted two composition turrets of circular section with oval tops, standing about 35 inches high; with 16-inch inlet and nine 3½-inch outlets, each one of the latter having a brass gate valve, and standard hose connection. The oval turret top should have a flange for a 5-inch gate valve, and over this valve should be mounted a nozzle of approved design. The cubic contents of each turret would be about 40 gallons.

An 8-inch line controlled by a gate valve should lead from the 16-inch main forward to the underside of the pilot house, from which a 5-inch branch should be carried up to supply the nozzle on top of the house. A 6-inch branch would supply the bow nozzle, and a 6-inch line led aft would supply the nozzle on the tower. Each turret and each line of pipe leading to the fixed nozzles should have a gate valve, leaving a clear water way controlling them, so that each fire-fighting unit is absolutely independent of the others, in case it is necessary to undertake repairs or reconstruction.

All valves 6 inches and over should be of the rising stem type; in this type the valve stem and nut are maintained from contact with the water, thereby avoiding sediment and incrustation. The ordinary brass-mounted, cast-iron valve provided with composition ring should be avoided, as the iron corrodes rapidly, thereby rendering the devices inoperative. Valves 6 inches and over should each be fitted with a by-pass so the pressure can be equalized on both faces when opening them.

The water tower should be about 27 feet in height above the deck, and provided with a platform or fighting top so constructed that one or two nozzles can be conveniently operated by men standing on the platform. The nozzles on the tower have been found most effective in fighting fires on piers with upper stories; a better range can be obtained with the elevated pipes than from those on the deck. This also is true of warehouse fires.

There should be two reels placed on deck for carrying 3½-inch, and one for carrying 2½-inch hose. Experience has shown that two sizes of hose are enough to carry; these are 3½-inch and 2½-inch. The first is the better for all around work; hose of larger size cannot be handled with celerity, and the smaller size is unsuited to the pumps. A powerful stream of water can be forced through a 3½-inch line with a 1¾-inch or 2-inch nozzle; if it becomes necessary to reduce the line for inside work a two-way siamese connection with 2½-inch hose and 1¼-inch nozzle will give two good streams.

The boat should carry 50 lengths 3½ and 25 lengths of 2½-inch hose; the practice of utilizing a hose wagon in responding to stations where fire boats are assigned is a good one. The service could be improved by using as auxiliary, a large motor-driven wagon, carrying 60 lengths of 3½-inch hose, and a full set of reducers, pipes, pipe-holders, etc.

The threads on all fixed nozzles should be in accordance with the fire department standard. I mention this because the manufacturers of the different pipes use different threads; in consequence the tips that fit one pipe will not fit a pipe made by another firm, and this will cause confusion and delay; therefore it is imperative that all tips be interchangeable.

The next subject of importance is that of a wharf or dock for berthing the boat. This should be at the center of the fire zone to be covered, or as near to the center as it is possible to obtain a location. The boat should be moored bow out in a berth free from all obstruction so she can respond instantly to a call.

In the important matter of selecting the members of the company care should be taken to assign men who understand a boat, and who have had experience at sea both in the engine room and on deck. It is bad policy to spend a large sum of money on the construction of a boat, and the installation of an expensive outfit, and then fail through lack of intelligent operation. The captain and lieutenant should not only be good firemen, but also good boatmen. The pilots should be men of long experience in the waters in which the boat is to operate; good pilots will keep down the cost of maintenance.

The engineer and his assistants should be thoroughly competent; in this case the cost of maintaining a boat can be kept down to the minimum; if other methods are pursued the cost will be high, and the boat often out of service. The firemen should be young and active; if enough men with boat experience can be found in your department they are the best to draft into this branch of the service.

The boat should be under steam at all times. This does not necessarily mean that she should be blowing off. But a steam pressure about 20 pounds below the tension of the spring of the safety valve should be constantly maintained; the pilot and engineer should be stationed on board.

No specific rules can be laid down to govern the important matter of handling boats at fires, but in all cases the first boat or boats to arrive at a pier fire should take position to leeward, and as close as possible, and the third boat to windward, if conditions warrant. Each chief knows best the conditions under which he is working, and governs himself accordingly.

Shore lines can be operated successfully at a distance of 500 feet; 3½-inch hose with 1¾ or 2-inch nozzles give the best results. A good up-to-date pipe holder should be used in order that the line may be thoroughly controlled, and effectively worked. If through accident or catastrophe the water service of a city should become impaired, a fire-boat company could stretch lines of 2,000 feet of 3½-inch hose; each of these 3½-inch lines would supply two fire engines of the largest size, which in turn could pump the water 1,200 feet more. This would be effected by putting a two-way connection on the 3½-inch line, with a male connection, the main line being arranged between two engines close enough to enable each to draw from it with its suction, or hydrant connection, and in this manner each boat could furnish water to 12 or 16 engines. It may be thought that 2,000 feet would be a great distance to force the water through 3½-inch hose, but it must not be forgotten that the engines would help as they would create a vacuum on the receiving side of the pump. Thus the water would have very little atmospheric resistance, and consequently would be forced along for a much greater distance than if discharged through a small nozzle against the atmospheric pressure.

In the foregoing I have endeavored to give as full and complete data on this important subject as time would permit. In order to do so, I have drawn on the chief in charge of the marine battalion of the New York Fire Department, who is a practical boatman, being both a licensed master and engineer. The subject is therefore discussed not from the standpoint of a marine architect, but from the practical standpoint of fireman, boatman, and engineer. A boat such as has been described, with a full equipment, can be constructed for the sum (approximately) of $130,000.

## NOTES ON THE DESIGN OF REINFORCED CONCRETE BEAMS.*

(1) CONCRETE reinforced with steel will not stretch more before cracking than plain concrete; and the unit elongation of the steel when the first minute crack appears is not greater than from 0.0001 inch to 0.0002 inch, corresponding to a unit stress in the steel of 3,000 to 6,000 pounds per square inch. Consequently the tensile resistance of concrete should not be taken into consideration in reinforced-concrete design.

(2) Until a method has been devised by means of which the coefficient of elasticity of concrete in a beam can be accurately determined, or until sufficient systematic tests have been made for the special purpose of determining the position of the neutral axis for different concretes and different percentages of steel, the neutral axis may, for practical purposes, be assumed to be 0.55 of the depth of the beam above the center of the steel for working loads on beams of rock concrete of good design; that is, where the concrete in compression is not excessively strong relative to the tensile resistance of the steel, and *vice versa*. This makes the lever arm of internal stresses 0.85 the depth.

(3) Horizontal reinforcement is not sufficient in beams of ordinary dimensions, but some provision must be made to transfer the tensile stress from the steel into the compressive area of the concrete.

(4) This can be satisfactorily accomplished for simple beams by running half of the number of reinforcing bars straight through the beam, and bending up the others at the loading points, half of the latter running to the top of beam at the end, and half to mid-depth of beam at end. The inclined cracks as they usually occur in a concrete beam are approximately perpendicular to the direction of these rods; and these rods are, therefore, very efficient in preventing this failure. In most reinforcement heretofore used with bent rods the angle of inclination with the horizontal has been too large, and, consequently, the adhesive area of the rods was too small. Numerous tests on both large and small beams have shown that these methods are not effective in preventing inclined tension failures.

(5) Anchoring the horizontal rods at the ends of a simple beam is of no benefit.

* From a Bulletin issued by the University of Wisconsin.

(6) With sufficient provision made for shearing stresses, the strength of a concrete beam can be accurately calculated if the yield point of the metal and the compressive strength of the concrete are known. The maximum compressive stress on the outer fiber may be safely taken somewhat larger than the stress as determined in cube form.

(7) With a good concrete and medium steel, and with equal factors of safety for concrete and steel, the per cent of metal may be made as high as 1.75 or 2 per cent without making the tension side stronger than the compressive side.

# ARTIFICIAL LIFE.

## THE WORK OF PROF. DELAGE.

THE recent work of Prof. Yves Delage, of the Paris University, has been followed with great attention, owing to the new light which it throws upon the absorbing question of parthenogenesis. This eminent biologist has made a great step in advance in the field of artificial fecundation, and we have already spoken of his latest work in this direction. Since then, Prof. Delage has presented another communication to the Académie des Sciences, describing some of the details of his process, and has also showed a specimen of sea urchin which he succeeded in producing by his new method. This work is carried on at the biological laboratory of Roscoff, of which he is the director. Three remarkable results are to be noted in the present researches. First, he succeeds for the first time in making the specimens of sea urchin pass from the state of larva to the final stage, in which the animals are in a perfect condition. Second, and what is probably the most important for future research, is the production of a sea urchin which is a variation from the normal type, seeing that it contains six divisions instead of five; there seeming to be scarcely a doubt that the chemical method is responsible for the change. Third, by a long and careful series of researches, he appears to have proved that artificial fecundation, contrary to the theories of Loeb and others, is not due either to osmotic action or to an electrolytic effect, and expects shortly to establish that it is not due to the action of oxygen and that this element is not indispensable for the fecundation. What is also striking is that he conceived a theory that artificial fecundation of the egg was caused by a series of coagulations and solutions of the membrane and that if such a process was once set up, it would be continued afterward without further aid. Accordingly he set about finding the proper solutions to carry out the coagulation and then the solution, and this resulted in his new tannin-ammonia treatment which we have already mentioned. He found that sea-urchin eggs and those of the asteria could be artificially hatched by this treatment, which seemed to prove that his theories were correct. This will throw a new light upon many interesting questions and no doubt bring out controversies which will aid in discovering other points in the future, and engage other experimenters to enter the field. Prof. Delage is now engaged in seeking for a complete explanation of all the phases of the phenomena of parthenogenesis, which constitutes one of the highest scientific problems, that of the origin of animal species and the sources of life. In his recent paper presented to the Académie des Sciences, Prof. Delage makes the following statements. He has obtained up to the present seven complete specimens of sea urchin from the larvæ, which passed through the stage of metamorphosis. Six of these specimens fixed themselves and climbed up the sides of the raising tank with their ambulacres. Of these six, one was lost, two died or were put in preparation as specimens, and three are now living. They were hatched from the eggs on the 17th of June and became complete sea urchins about the 18th of August. They have grown considerably since their formation. The author presented one of the specimens to the academy. It exhibits a characteristic which is extremely curious, a variation which is without precedent. We find here a hexagonal symmetry, and there are six divisions in the shell of the animal, six terminal tentacles and six pairs of ambulacres instead of five, as usual. These details can be observed very clearly in the specimen, which is now living in the experimental tank at Roscoff. Although variations in the number of divisions are frequent in the Asterias, they seem to be without example in the case of the sea urchin, and the author does not know of any case which is published. None of the persons he consulted on the subject had ever seen such a specimen, nor had the author himself, among the thousands of sea urchins which he opened in order to extract the eggs for his researches. The other parthenogenic individuals which he obtained did not appear to show this peculiarity, so that he is unable to assert that it is a necessary consequence of the chemical method used. Nevertheless, this chemical origin seems to be responsible for an unprecedented case of variation. As concerns the Asterias (*Asterias glacialis*) he stated in his previous communication that some of the parthenogenic larvæ seemed to be upon the point of becoming fixed. At present two of them have become so and are now transformed into small asterias. One of these is minute and scarcely mobile, while the other specimen is vigorous and quite active. In a few minutes it covers an inch or more distance upon the side of the vessel. This latter specimen measures 1 millimeter across (1/25 inch) and has grown nearly 0.5 millimeter since its fixation, which occurred on the first of September. It is in the form of a St. Andrew's cross with five branches, and shows very long and very mobile ambulacres with which it shifts its position. All traces of the larval structure have disappeared. In order to bring this interesting specimen to the adult stage, it will be necessary to find a method of feeding, a thing the author is not certain that he will be able to accomplish.

### THE AGE OF THE EARTH.

IN the Proceedings of the American Philosophical Society, Prof. T. J. J. See, U. S. N., has a memoir on the cooling of the earth and the theory of earthquakes held by the ancients. In part the memoir is a further elaboration of the paper published last March by Prof. See to show that earthquakes are due primarily to the seepage of water through the ocean's bottom.

For almost a century scientists generally have held that the earth is cooling, and therefore slowly contracting. In this way they explain earthquakes and mountain formations. Now comes Prof. See with an elaborate argument more exhaustive than that of Lord Kelvin, tending to show that the effects of secular cooling of the globe are insensible, and totally denying the contraction of the earth.

Prof. See's memoirs may be summarized as follows: The earth's temperature has an elliptical distribution within, of about 8,300 deg. Fahrenheit at the center, falling off toward the surface, where it is zero. As the earth slowly cooled, the crust was the only part which experienced an appreciable fall in temperature.

Hence the crust is thin, with a thickness of not more than twenty miles, which agrees with the depth deduced from the study of the world-shaking earthquakes. The great earthquakes originate at the depth of about twenty miles, and none is known of a depth exceeding forty miles.

As the earthquakes all have superficial origin, and no shakes have a deeper source, it follows that there is no deep-seated contraction of the earth. Consequently all changes in the crust are due to ordinary earthquakes, and to no other cause.

Secular cooling is infinitely slow, and affects only the crust, whereas world-shaking earthquakes proceed from the layer just beneath the crust. As earthquakes occur mainly along the seacoast, they cannot depend on secular cooling, but must be due to the expulsion of lava from beneath the oceans.

Hence great earthquakes are not due to secular cooling at all, but to the leakage of the oceans, which produces steam beneath the crust. This eventually pushes out at the sides and raises mountains along the coasts.

As the effects of secular cooling are insensible, it follows that the earth is not contracting, as held in the books for three generations. Dr. See shows, indeed, that at an early stage of the earth's history contraction was going on, but it ceased after our planet became incrusted. In fact, he thinks that so far from contracting, the earth may now be slightly expanding, owing to the formation of pumice everywhere beneath the crust.

The old theories that mountains are due to the secular cooling and contraction of the globe must therefore be abandoned. The mountains are formed by the expulsion of lava from beneath the sea, and hence they are parallel to the coast.

Dr. See concludes by a mathematical inquiry that the age of our incrusted earth does not exceed some ten million years, which is a much shorter time than geologists have generally allowed. He also finds that radium plays no important part in the development of the globe.

Prof. See translates Aristotle's theory of earthquakes, which has never before been made accessible to English readers. The Greeks all held that earthquakes were due to the agitation of vapors within the earth, which tended to escape and diffuse themselves in the atmosphere. Aristotle observed the eruption of a volcano and concluded from the vapor he noticed to escape that all earthquakes were due to the same cause as that producing eruptions.

When Plato was 54 and at the head of the Academy in Athens and Aristotle was a boy 11 years old the Homeric city of Helike, on the southern shore of the Gulf of Corinth, was thrown down by an earthquake and overwhelmed by a seismic sea wave.

The cause of this disaster perplexed the Athenian sages, and has remained one of the mysteries of the centuries. Now comes Prof. See, who shows that it was due simply to the expulsion of lava from beneath the Gulf of Corinth, which thus made the sea bottom unstable, and when it gave way it also carried the shore on which Helike stood; indeed, the city was first devastated by the movement of lava beneath the crust and afterward subsided about one hundred feet, so that it was covered by the waves until only the tops of trees remained above water.

Besides the sinking of Helike, other cases of the subsidence of the land are mentioned, and in the concluding note attention is called to the elevation of the mountains and the sinking of the sea bottom now going on in the vicinity of the Aleutian and Kurile islands, in the north Pacific.

### DETERMINATION OF MELTING POINTS OF METALS.

THE determinations of the melting points of metals offer certain difficulties. When we possess a sufficient bulk of the metal, we melt it in a crucible. This may be done in an indifferent atmosphere or under a layer of some flux which prevents access of the air. The lumps of metal will always have gases condensed upon them, however, and we are, hence, not dealing with pure substances. The same conditions will, however, prevail in practical operations, and the crucible method is therefore, on the whole, the best, provided that we can avoid contamination with the materials of the crucible and other substances. The temperature is determined by dipping some electric thermometer or a thermo-couple, protected by a tube of fire-clay, into the metal. The temperature will keep constant about the melting and freezing points, which can thus easily be determined. When we have only small masses of the metal or alloy at our disposal, the task is more difficult. Berthelot proposed to fix a short length of wire of the respective metal between two platinum wires, and bring it as near the ends of the thermo-couple as possible in an electric or other furnace. The observer had then to wait for the melting of the wire, and simultaneously to read off the momentary temperature. As this is not easily done, Holborn and Day have placed the piece of wire in question between the two wires of the thermo-junction. When the test-wire melts, the thermo-current is momentarily interrupted, the galvano-meter will swing back and the exact temperature is thus marked. But Holborn and Day did not deceive themselves as to the objections to the method. Working in air the wire will be oxidized, while in a reducing atmosphere the thermo couple is exposed to the contaminating influence of the carbon monoxide generated in the carbon furnace usually employed. The sudden deflection of the galvanometer is easily overlooked, moreover, because the bead of the molten wire immediately closes the circuit again. This bead spoils the thermo-junction, so that the couple has to be shortened after each test. Another simple method—a modification of the Berthelot method—has recently been worked out by Richard Loebe, of Berlin. According to the Zeitschrift fuer Elektrochemie, Loebe returns to the idea of Berthelot, and keeps the thermo junction and the test-wire circuit entirely separate. The operations are carried out in an electrically-heated crucible, into which are lowered the leads of the thermo-couple, and close to them the platinum leads, between which the test-wire is stretched. This wire should not be too short, at least 5 millimeters in length, so that the molten metal drops off and does not form a bead, which would unite the two terminals. The circuit of the two platinum wires further contains a little battery and an electro-magnet, whose armature strikes against a bell; that is to say, it is simply a bell circuit, which is normally closed, and which is interrupted when the wire melts. The observer keeps his eye on the galvanometer of the thermo-couple, and takes a reading when the bell sounds; the observation is hence not so trying as with the other methods in which a momentary deflection of the galvanometer has to be waited for. The crucible may be charged with fluxes or with indifferent gases, and may be placed into a metallic bath; the platinum leads may be incased in a tube of fireclay. Although there is nothing very striking about Loebe's method, it certainly appears to simplify the determinations considerably.

**While common glass** will crumble when exposed to great heat, experiments show that when mixed with hydeslite it will bend or roll hot, neither breaking nor crumbling.

# THE DEVELOPMENT OF ARMORED WAR VESSELS.—XIII.

## ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

Continued from Supplement No. 1663, page 310.

AT the time of the appointment of the original Advisory Naval Board there were but two types of armor in use by the naval powers of Europe; the English favoring the compound armor, having a hard steel face welded to a tough iron back, the face being about one-third the thickness of the whole plate. The French favored an all-steel plate, having a hardness and toughness designed to stop and break the projectile fired at it. The navy of Great Britain at this period had as their largest armored vessel the "Inflexible," completed in 1881, having a side armor protecting the vital parts of the vessel of 24 inches, 20 inches, and 16 inches; also two others then building, the "Ajax" and the "Agamemnon," each having 18 inches side armor. The French navy had the "Admiral Baudin," the "Admiral Duperré," and the "Formidable," each having armor of the greatest thickness of 21½ inches. They also had four frigates then building at the time, upon which armor of 18 inches in thickness was fitted. Comparisons may be unpopular, but this shows to what a low condition our navy had fallen in its type of vessels in about sixteen years.

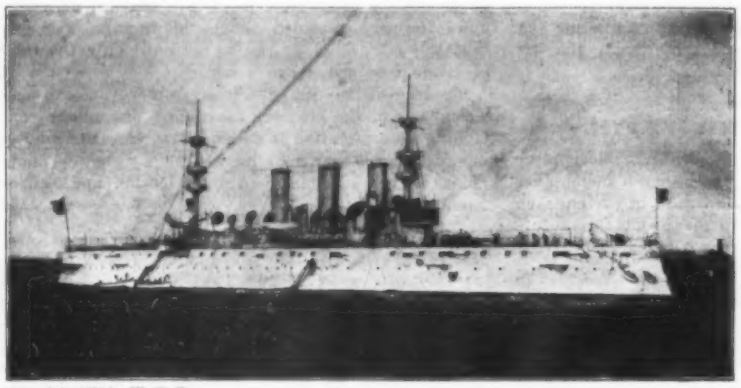
The first steel *armored* vessels of our modern navy were the second-class battleships, the ill-fated "Maine" and the "Texas." The keel of the former was laid at the Brooklyn navy yard in October, 1888, and her side armor was 12 inches thick, turrets 8 inches, and barbettes 12 inches. The "Texas" was built at the Norfolk navy yard, the keel being laid in June, 1889. The side and redoubt armor was 12 inches thick.

The pioneer first-class battleships were the "Indiana," the "Massachusetts," and the renowned "Oregon"; their keels being laid in May, June, and November, 1891, respectively. The side armor was 18 inches, the main turrets 15 inches, and the casemates 5 inches thick.

The armored cruisers "New York," whose keel was laid in September, 1890, and the "Brooklyn," whose keel was laid in August, 1893, were afforded protection to the hull by means of a steel protective deck running from stem to stern of the vessel, having a thickness of 6 inches on the slope over the machinery and boiler spaces, and on the flat part of deck 3 inches thick. Protection to the hull along the waterline is obtained by means of an armor belt, 4 inches thick on the "New York" and 3 inches on the "Brooklyn," covering machinery and boiler spaces, and 4 feet above and 4 feet below the load waterline. The turret armor on the "New York" is 5½ inches and barbette armor 10 inches. Turret armor on the "Brooklyn" is 5½ inches, and barbette armor 8 inches and 4 inches.

The triple-screw protected cruisers "Columbia" of 1890 and the "Minneapolis" of 1891, the "Pirates," have each a protective deck extending the entire length of the vessel, and is made up of two courses of 1¼-inch nickel steel, and on the slopes increased by an additional course of 1½ inches, making 4 inches; and for the remainder of the deck, 2½ inches.

The protective deck was first carried the entire length of the vessel, dropping at the ends below the waterline,



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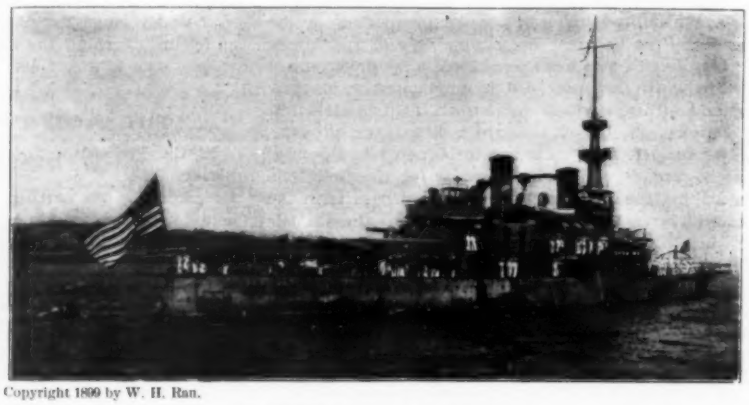
ARMORED CRUISER "NEW YORK."



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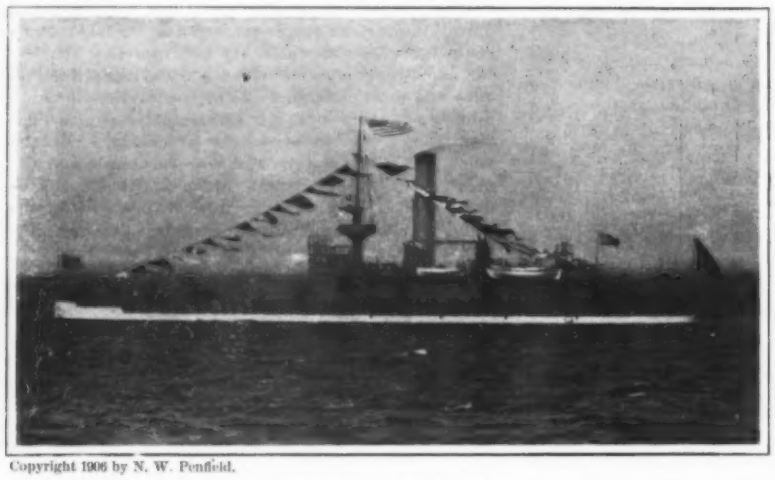
BATTLESHIP "OREGON."



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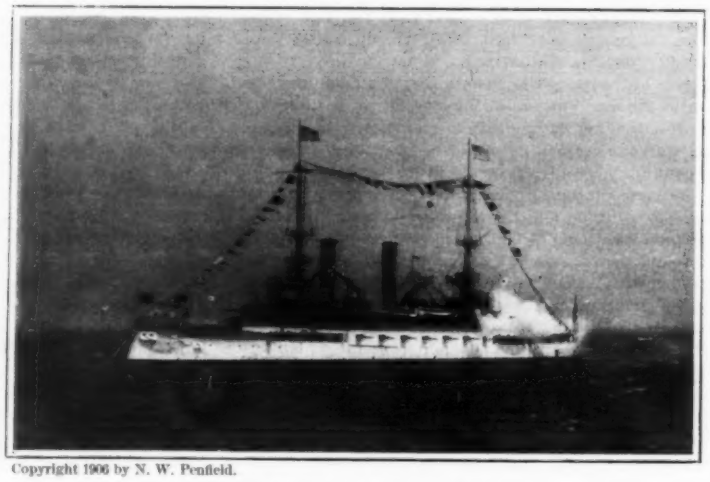
MONITOR "FLORIDA."



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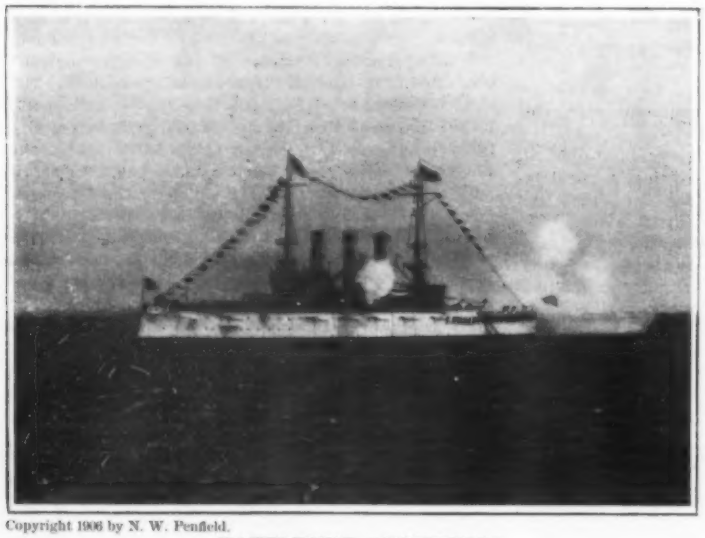
BATTLESHIP "KEARSARGE."



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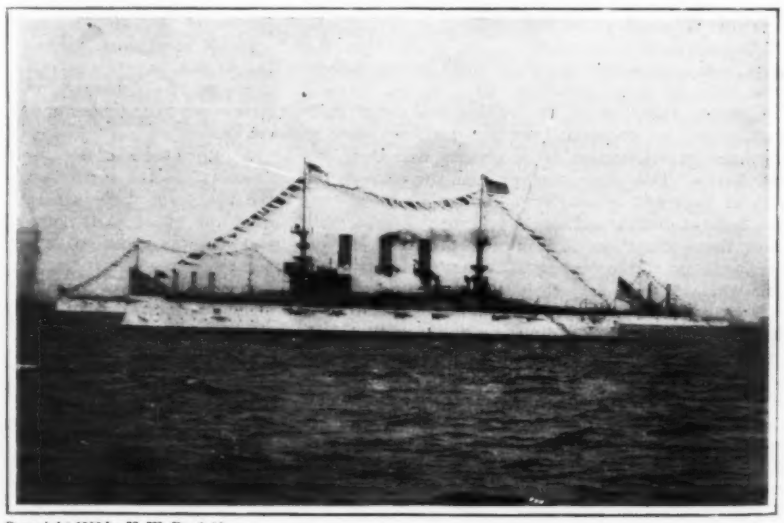
BATTLESHIP "MISSOURI."



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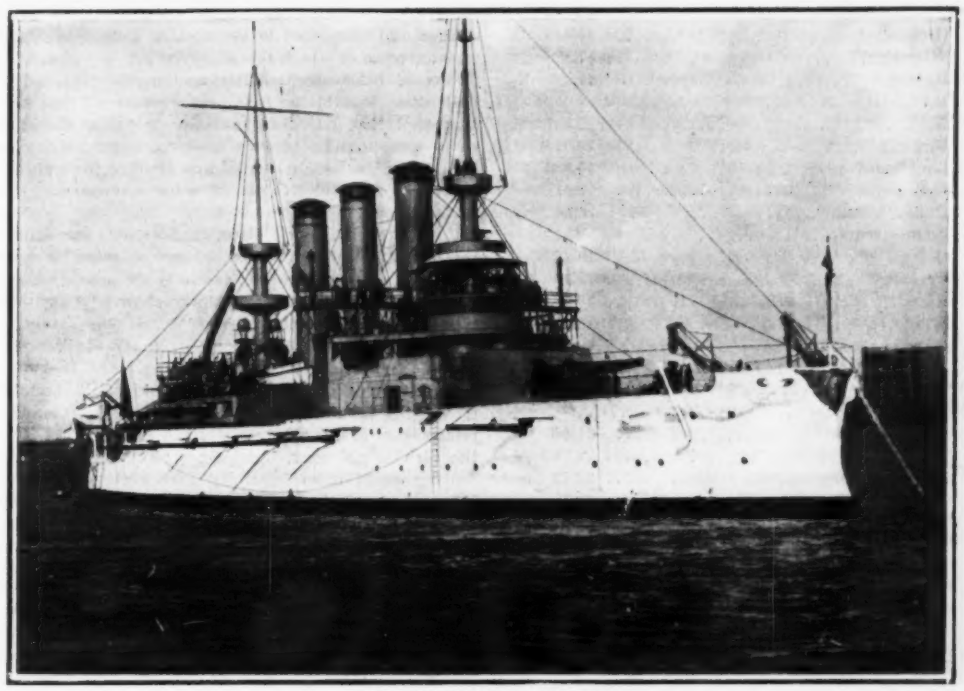
BATTLESHIP "LOUISIANA."

in our new navy, in the "Charleston" type of cruisers built in 1887.

To see what changes have been made in the dimensions of the hulls and the armor of the several types of our armored naval vessels built within the last twenty years, we have but to refer to the table given below.

The construction of the armored vessels of our modern navy did not progress toward completion with the same rapidity in the earlier vessels as they did at a later date, mainly on account of the armor plate not being ready for delivery to the Navy Department when the vessels under construction were ready to receive it. This class of work was altogether new to our shipbuilders at first, but they soon mastered the details. With the improved labor-saving machinery for such heavy work, they soon began to take place with the best builders of armored naval vessels in the world. The record shows that the "Maine" was launched in November, 1890, and the "Texas" in June, 1892, and that the former was not placed in commission until September, 1895, and the latter in the month previous. The first-class battleships to be placed in commission were the "Indiana" in November, 1895, the "Massachusetts" and the "Oregon" followed in June and July, 1896, respectively, and the "Iowa" in June, 1897. At this time the battleships "Kearsarge," "Kentucky," "Alabama," "Illinois," and "Wisconsin" were under construction. The other active vessels of the U. S. navy at this time were composed of thirteen of the unarmored protective cruiser type, three unprotected cruisers, four monitors, several gunboats, and five torpedo boats. The opening of the Spanish-American war found us with but five battleships, two armored cruisers, the six double-turret monitors, and five of the old single-turret monitors as the armored portion of our navy—not a very imposing fleet in numbers nor in types.



BATTLESHIP "OHIO."

It is since 1898 that the greatest development of our armored naval vessels has taken place. The marked advance that has been made since then in the construction of our naval guns has caused our naval constructors to increase the size of the vessels, with greater defensive power in the later armored vessels. Then with the increased freeboard of the battleships, the extension of the protective deck, and the increased area of waterline armor belt, we have as high a class of fighting machine in our battleships as any naval power in the world. The latest armored cruisers have been so armored and protected as to be almost second-class battleships. Since the close of the Russian-Japanese war there have been different opinions entertained by expert naval constructors and the higher naval officers the world over as to the lessons taught the naval designer during this war; but the general opinion seems to be at this stage of the discussion, that for the future a still larger vessel with increased speed and increased offensive gun power, for a battleship, than the most modern vessels now in commission is demanded.

If the practice of adding "system" after "system" in the new vessels continues, it will be but a short time before the combined auxiliaries will be greater than the capacity of the vessel to hold them. With all the electrical, pneumatic, hydraulic, and steam appliances for the protection and operation of the vessel at present, it may be difficult in the near future to find room for the machinery for the propulsion of the vessel, unless some design that occupies less room in a vessel than the triple-expansion engine and water-tube boilers now demand. Possibly, the development of the turbine engine may solve the problem.

To note the marked advance that has been made in the size of our armored and protected vessels, we have but to take the second-class battleship "Texas," of 6,000 tons, with the "Vermont," a first-class battleship of 16,000 tons; and in the cruiser type, of the "Chicago," a protected cruiser only, of 5,000 tons, with the "Washington," an armored cruiser of 14,000 tons, all in the space of twenty years. That was making history very fast. There was a period of about fifteen years, ending in 1882, when the Navy Department had, it seems, no time to make any improvement of our naval vessels, only to build up a wooden vessel on an old keel, and call it "repairs." What a farce that was!

Since then the material conditions of the country have largely developed, and a progressive spirit has been manifest in every move of the Navy Department in the construction of vessels, to obtain the best fleet of vessels of domestic material and construction that experience and science can suggest. They certainly have made marked progress in the short time they have been occupied in building the improved types of vessels, and the naval constructors will no doubt give a good account of their skill in the future.

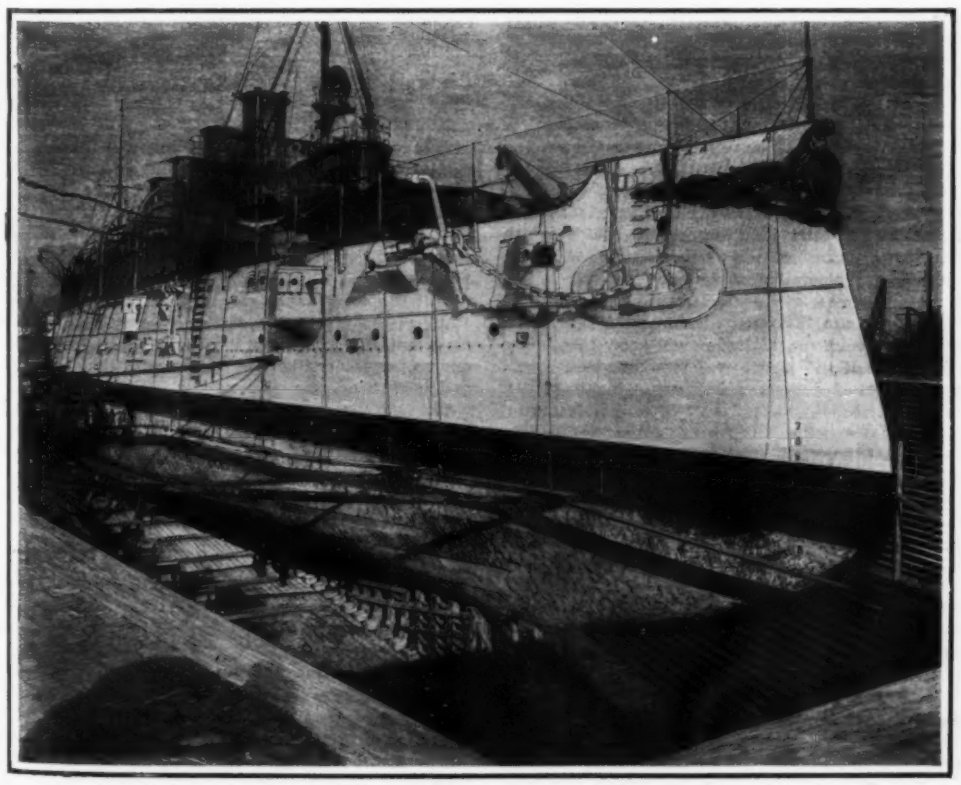
Congress must take some of the responsibility for the dilatory rebuilding of our navy, in refusing to appropriate money for the specific object of constructing the iron or steel vessels at an earlier date. Probably they may say it was a blessing in disguise, but it is doubtful if Congress so intended it at the time.

BATTLESHIPS.

| | Keel Laid. | Dimensions. | Armor. Waterline belt. | Turrets. |
|---|---|---|---|---|
| "Texas," 2d class..... | June, 1889 | 301.4 x 64 x 22.6 | 12 in. | 12 in. |
| "Oregon," 1st class..... | Nov., 1891 | 348 x 69.3 x 24 | 18 in. | 15 and 6 in. |
| "Alabama," 1st class..... | Dec., 1896 | 368 x 72.2 x 23.6 | Top 16½ in.<br>Bot. 9½ in.<br>W. L. 13¾ in. | 14 in. |
| "Kearsarge," 1st class... | June, 1896 | 368 x 72.2 x 23.6 | 16½ in., 9½ in., 13¾ in. | 17 in.<br>15 in.<br>11 in.<br>9 in. |
| "Maine," 1st class..... | Feb., 1899 | 388 x 72.2 x 23.6 | 11 and 7½ in. | 12 and 11 in. |
| "Rhode Island," 1st class. | May, 1902 | 435 x 76.2 x 23.9 | 11 and 8 in. | 12 in.<br>8 in.<br>6½ in.<br>6 in. |
| "Louisiana," 1st class.... | Feb., 1903 | 450 x 76.10 x 24.6 | 11 and 9 in. | 12, 8 and 6 in. |

ARMORED CRUISERS.

| | Keel Laid. | Dimensions. | Armor. Waterline belt. | Turrets. |
|---|---|---|---|---|
| "New York" ..... | Sept., 1890 | 380.6 x 64.10 x 23.3 | 4 in. | 5½ in. |
| "Brooklyn" ..... | Aug., 1893 | 400.6 x 64.8 x 24 | 3 in. | 5½ in. |
| "West Virginia" ..... | Sept., 1901 | 502 x 69.6 x 24 | 6 and 5 in. | 6½ and 6 in. |
| "Tennessee" ..... | June, 1903 | 502 x 72.10 x 25 | 5 and 3 in. | 9, 7, and 5 in. |



THE CRUISER "COLUMBIA" IN DRYDOCK.

SPEED TRIALS OF ARMORED VESSELS OF THE UNITED STATES NAVY.

| *Battleships.* | Knots. |
|---|---|
| "Indiana" ..... | 15.55 |
| "Massachusetts" ..... | 16.20 |
| "Oregon" ..... | 16.79 |
| "Iowa" ..... | 17.09 |
| "Kearsarge" ..... | 16.816 |
| "Kentucky" ..... | 16.897 |
| "Alabama" ..... | 17.013 |

| | Knots. |
|---|---|
| "Illinois" | 17.449 |
| "Wisconsin" | 17.17 |
| "Maine" | 18 |
| "Missouri" | 18.05 |
| "Ohio" | 17.817 |
| "Virginia" | 19.01 |
| "Louisiana" | 18.823 |
| "New Jersey" | 19.01 |
| "Rhode Island" | 19.18 |
| "Connecticut" | .... |
| "Georgia" | 19.26 |
| "Vermont" | 18.33 |
| "Kansas" | 18.096 |
| "Minnesota" | 18.851 |
| "Nebraska" | 19.06 |
| *Armored Cruisers.* | |
| "Brooklyn" | 21.91 |
| "New York" | 21. |
| "Colorado" | 22.24 |
| "Maryland" | 22.31 |
| "Pennsylvania" | 22.43 |
| "Tennessee" | 22.16 |
| "Washington" | 22.41 |
| "West Virginia" | 22.14 |
| "California" | 22.2 |
| "South Dakota" | 22.128 |

(To be continued.)

## THE LIMITS OF THE MIND AND THE LIMITS OF REALITY.

THAT which is small or large relatively to his own person, man regards as absolutely small or large. Man has a taste for ultimates in both directions. He will confidently, observes London Knowledge, criticising opponents of the "new" physics, describe earth, air, fire and water as ultimate elements, and when these are replaced by more elemental bodies in his categories he confidently labels the newly found as atoms or "uncuttables." A later generation anatomizes the atom. Thereupon the electron is hailed as the ultimate of ultimates, further than which no one can go. Similarly in the other direction, we pass from the geocentric conception of the universe to the heliocentric and from that to the idea of a finite and solitary universe of which the Milky Way is the rim. Any notion of other such stellar systems is regarded as ludicrous. Within the past year, however, it has been suggested that our stellar system is really the transient commingling of two systems, apparently quite independent in origin, which are drifting through and past each other, and to one of which our sun and ourselves belong.

Prof. Fournier has done much for this thesis through his lectures before bodies of scientific men. Recognizing the ultimate invalidity of man's criteria both of space and time, he seeks to show how our man-measured ideas have any basis at all. He seeks to show the difference between the limits of the mind and the limits of reality. We may conceive the world known to us as merely one of an indefinite number of varying magnitudes as to which we can predicate relative size only, absolute size not at all. Of course, the idea is not new, but only within this twentieth century could it so fruitfully have been worked out. True, we could observe the analogy between the social and the individual organism and between the latter, a society of many cells, and the single-celled creatures, which are societies of many molecules. Similarly we could conceive of the larger molecules as societies of many atoms; but there, having reached what we were pleased to regard as an ultimate, we had to stop. Everyone is now familiar, however, with the analogy between an atom and a solar system. The attractive center or "sun" of the atom is a core of what we somewhat vaguely call "positive electricity," for gravitational attraction is substituted electric attraction, and for planets we have electrons or particles of "negative electricity" which revolve around the center and, relatively to their size, are quite as far apart as Jupiter and Mars from the earth:

"If, now, any one should suggest, as Mr. Fournier does, that possibly the electrons or 'planets of the infra-world' are inhabited, we protest; but our ultimate argument is that these things are altogether too small for such possibilities, and thus the ultimate appeal is to psychology. Assuredly, however, nothing is small or great, but thinking makes it so, and we have no more warrant for our conclusion than would an 'infra-man' for a similar skepticism as to the life of bodies made up of what to him are solar systems and to us are atoms.

"Turn with Mr. Fournier to the conception of a supra-world, and we begin to realize that our ordinary notions have no more real validity than, let us say, would the notions of one of our blood corpuscles as to the nature of the stream in which it finds itself, or the channels in which that stream runs. To such corpuscle itself is its own end, and it would be highly astonished on being told that it was really only one of countless billions which are regarded merely as subordinate parts of an organism, no less alive than itself, the dimensions of which, relatively to the corpuscle, are perhaps as great as the dimensions of the solar system, or indeed the stellar system to ourselves. If the size and anatomy of man were revealed to one of his tiny constituent cells would they not appear as merely mechanical, insentient, and monstrous as the stellar heavens do to us, looking upon them from within?

"In the light of such considerations, many of our taken-for-granted notions are seen to be meaningless. Our solar system, with its planets and their planets or moons, may quite fairly be likened to a constituent atom of the mighty molecule or organism, perhaps, which we call the stellar universe; the number of such atoms or solar systems constituting our particular stellar system, say one hundred millions, is by no means incomparable with the number which must be contained in the smallest living organism known (as such) to us. The relative brevity of human life is an irrelevant consideration if once we disabuse ourselves of the uncritical metaphysical assumptions which are so earnestly credited by those who flatter themselves that they are superior to all 'mere metaphysics.' To regard the secular movements of the stars as absolutely 'long' is as unwarrantable as to regard the year of an electron—its period of rotation within the atom—as absolutely short."

# KEFIR AND YOHOURTH.

## LACTIC SUBSTANCES THAT PROMOTE HEALTH.

THE interest of the scientific world was recently aroused by the work of Prof. Metschnikoff, of Paris, and connected with the Pasteur Institute, upon fermented lactic bodies, which were found to have a highly beneficial action upon the organism. Such bodies are formed by causing the fermentation of milk by the products of certain grains or plants coming from the Caucasus or the Balkan regions. Prof. Metschnikoff's attention was called to the fact that the action of such products upon the system is powerfully antiseptic and tends to destroy certain microbes which act as poisons. He claims that their use will tend to restore health generally and even to lengthen life; while in certain diseases the action is powerful. But hitherto it has been almost impossible to procure these products on a practical scale. This want is now filled by the Carrion Laboratory, of Paris, which is now preparing them for general use. These two products are known as kefir and yohourth. What is known as kefir is the product of a special fermentation of milk. This fermentation is the work of certain micro-organisms whose observation is now carried on by different scientists, especially since the remarkable therapeutic and hygienic properties of kefir were established and promulgated first by Russian doctors and then in all countries. The microscope reveals in kefir two kinds of ferments which are especially important, a yeast principle known as *saccharomyces kefir*, whose characteristics are analogous to those of beer and the grape, and also a bacillus whose name, *bacillus caucasicus*, has reference to its far-off origin. It is shown that neither of the germs which participate in the kefiric fermentation is alone capable of full fermentation. For this it is necessary that they act in concert. Again, the kefiric fermentation will be carried out in a defective manner if foreign bacteria, which are veritable parasites, enter into the field in an appreciable quantity.

Hence, there are two kinds of precautions to be taken, first to keep up the harmony between the micro-organisms which accomplish the fermentation, and second, to exclude the parasites. The precautions are more needed in our countries than in the regions where the kefir is a native. Fortunately, since Pasteur's discoveries, we have the means of realizing them everywhere. What is needed is to supply pure milk with the pure germs. The method of keeping the germs in the pure state is one which belongs to the domain of laboratory processes, and cannot be dwelt upon at present.

What is specially to be noticed is the destructive part played by kefir upon the microbes and microbian poisons in the digestive tube. Kefir, in fact, possesses the properties of a living organism, seeing that special micro-organisms abound in it. These are agents of lactic fermentation and antagonists of putrid fermentations. Hence its important hygienic and therapeutic properties which have been brought out by M. Metschnikoff. It is a known fact that in the intestine, even in healthy persons, and much more so in dyspeptics, dangerous microbes are abundant. These are dangerous because they may be introduced into the organism and thus infect it, and also because they produce soluble poisons, and these latter can pass into the blood more easily than microbes. This kind of poisoning, whose source is in the intestine, is not always traced to its real cause. The organism, healthy in appearance, is in reality undermined by this permanent kind of poisoning, and M. Metschnikoff considers that such deleterious influence shortens the period of youth, hastens decay, and abridges the natural longevity of man. By suppressing it we delay old age and death.

But it may be asked how we may act upon the cavity of the intestines itself. Should we seek to accomplish this effect by antiseptic products, we find these to be poisons which are still more dangerous for us than for the microbes. The process which M. Metschnikoff points out is, on the contrary, inoffensive and simple. To the infinitely small bodies which harm us, we oppose others of the same kind which are not by any means harmful to us, but even useful to a certain extent, and are active antagonists to the former. Such are the micro-organisms of kefir. His observations and those of M. Rovighi show that under the influence of the kefiric regime we find an actual disappearance of certain substances which show a poisoning of the organism due to intestinal fermentation. Thus the kefir acts as an antiseptic for the intestine, and besides is not a medicine but an aliment of the highest order.

Seeing that it is produced from milk, kefir contains the primitive elements of milk, and is thus a complete food. Moreover, the fermentive bodies and the soluble ferments which go to produce the kefiric fermentation operate upon the albuminoid matter of the milk and give precisely a part of the changes which are usually carried out by the ferments of the digestive tube. Thus the micro-organisms of kefir co-operate with the glands of the stomach and the intestine and lighten their task and complete their action. In this way, taking an equal duration, the digestion of kefir will be more nearly perfect than that of milk. To an equal degree of perfection, it will be more rapid. This is not simply a theory, but is a fact which has been proved experimentally by Profs. Gilbert and Chassevant, of Paris, after thorough tests. They administered kefir to animals, or milk on the other hand, and found that the former always remains a shorter time in the stomach. Thus we find the properties of kefir to be a great digestibility and a high nutritive value.

Kefir has the physical and organoleptic qualities which are connected with the ferments contained in it. We may mention some of these properties, and we find that they change slightly as the fermentation goes on in the course of time. This body has an acid reaction, which is due to lactic acid, this latter being developed by the partial transformation of milk sugar. It is also somewhat gaseous or "sparkling." This is due to the carbonic acid gas which is given off by the fermentation. It has somewhat the appearance of cream, owing to the state of the albuminoid matter, this being in the form of a very fine precipitate which, when the whole is shaken up, remains in suspension for some time. When allowed to stand for a long time the kefir separates into two layers. One of these contains the above-mentioned albuminoid precipitate, which is lightened and made to float by the minute gas bubbles. Fermentation gives rise to these modifications in a progressive manner, and we have different stages or varieties of kefir, according to the time, lasting from one to three days. The acidity and the fluidity increase with the duration. Temperature and other conditions have a certain influence here. As to the dose, 10 to 20 fluid ounces per day is the average, and it should be taken slowly to have the best effect. It takes the place of other food, where this is necessary, but for many cases even as much as 40 fluid ounces per day can be taken along with the usual food, and it even acts as an appetizer.

The kefir can now be prepared on the spot by means of a substance in the form of powder, known as kefirogene. It is prepared in the laboratory and contains the special agents of the kefiric fermentation in a living state. This substance is not obtained from the dry grain of the kefir, but with a must of kefir culture in full activity. To produce the kefir, the powder is added to bottles of boiled milk provided with a patent stopper, and it causes a fermentation of the milk, giving rise to the product described above. From two to three days is the time required, and the temperature is kept near 68 deg. F. during this time.

A similar product which has received considerable attention of late is known as yohourth. While the kefir comes from the Caucasus region, the latter product is taken from Bulgaria or the neighboring regions, where its use is general and its dietetic qualities recognized. While it has the same general properties, it differs from kefir in its consistence and taste, seeing

that it is a semi-solid, like soft cheese. Its taste is agreeable, and pleases at once, while kefir, being more acid, sometimes requires some days' habit to become reconciled to it. However, in the yohourth the microorganisms are less abundant, and the albuminoid matter is less modified. In the same way as above mentioned, a dry powder is now prepared, known as yohourthogene, by which this product can be made when desired from milk.

## PURPLE BACTERIA.

By Prof. A. NESTLER.

PECULIAR organisms known as sulphur bacteria are often found in stagnant and even in running water, salt or fresh, which contains large quantities of decomposing organic matter. Imbedded in the cell substance of these bacteria are numerous microscopic pellets of pure sulphur. Some of the bacteria are colorless, others are red or purple and betray their presence to the naked eye by their color when they occur in large numbers. A few of the purple bacteria were discovered and described early in the nineteenth century, but the researches of Engelmann and Winogradsky first made known the curious movements and other remarkable peculiarities of these extremely interesting organisms.

Prof. H. Molisch has recently published* the results of several years of study of purple bacteria. A few of his most interesting discoveries are briefly described in this article.

If a little pressed hay is put in the bottom of a tall and narrow glass jar or large test tube and the vessel is filled to the brim with water from a pond or stream, covered with a pane of glass, and set in a window exposed to the direct rays of the sun, the water soon becomes filled with infusoria, green algæ, flagellates, and other organisms. After a few weeks in summer, or a somewhat longer period in winter, the liquid assumes a red color which gradually extends upward from the bottom and a red deposit is formed on the hay and the wall of the vessel. A soft-boiled egg, a bone with a little adhering meat, or a few dead earthworms or snails may be substituted for the hay. If the surface of the water is covered with a layer of oil the purple bacteria multiply so rapidly that a fine reddish violet coloration is obtained in a short time in sunny weather. Marine species of purple bacteria can be obtained by using seaweed and sea water.

The success of these methods of culture proves that purple bacteria are very widely distributed in nature. Molisch succeeded in obtaining pure cultures of a number of previously unknown species, of which the most interesting are distinguished by the absence of the sulphur nodules which are characteristic of the family in general. Many species are surrounded by a mucous envelope which can be made visible by adding a little India ink to the culture liquid.

Purple bacteria are remarkable for their need of abundant light, which is fatal to most bacteria, and also for their extremely small consumption of oxygen. They begin to develop at the bottom of the vessel and flourish best when the air is excluded by a film of oil. Many species can live and thrive for an astonishingly long time without any oxygen whatever. Numerous bacteria of the marine genus *Chromatium*, which had been sealed in a drop of water between a microscope slide and cover glass, with Canada balsam, in May, 1906, remained as lively as ever in March, 1907.

If an individual alga of the species *Pleurococcus vulgaris*, which is found as a green deposit on trees and varies from 1/12,000 to 1/4,000 inch in diameter, is placed in the center of a colony of active purple bacteria (there are also motionless species) on a microscope slide, the bacteria scatter in all directions, leaving an empty space, because they cannot endure the infinitesimal quantity of oxygen exhaled by the microscopic alga under the influence of light. Now, if the production of oxygen is interrupted by shielding the alga from the light, the clear space becomes filled with bacteria in half a minute, and it is cleared as quickly when the alga is again exposed to light. Hence these purple bacteria furnish a very delicate test for the presence of oxygen in quantities too small to be detected by any chemical reaction.

By this and other experiments, Molisch has proved that the pigment of the purple bacteria does not, as had been supposed, resemble the chlorophyl of green plants in performing functions of assimilation.

Even without the presence of algæ, the active purple bacteria exhibit a sensitiveness to light that may fairly be called marvelous. This is most conspicuous in the species which Molisch has named *Rhodospirillum photometricum*. The individuals of this species are comparatively large (1/5,000 to 1/2,000 inch long and 1/18,000 inch thick) and are easily visible with a power of 300 diameters. They are shaped like a corkscrew and they rotate and move to and fro in straight lines with great velocity. If the field is darkened for a fraction of a second by passing the hand over the illuminating mirror the bacteria instantly reverse their movements of rotation and progression. This astonishing phenomenon must be seen to be fully appreciated. It is characteristic of all active purple bacteria and it furnishes a valuable means of identification, for except in the largest species the color is apparent only in masses, not in single individuals. And as Molisch has indicated the simple method already described for obtaining purple bacteria, it is easy for any possessor of a good microscope to observe this sudden recoil, which seems like a movement of fear.

If a piece of black paper perforated by a hole of the size of the microscope diaphragm is placed beneath a slide on which is a drop of culture liquid flattened by a cover glass, and all top and side light is cut off by screens, all the bacteria in the extended drop will congregate in the little illuminated circle within a few minutes and will remain there, darting back toward the center whenever their movements bring them to the circumference.

According to Molisch, the coloring matter of the purple bacteria contains a reddish purple pigment, and also a green pigment. The latter, bacteriochlorin, has nothing in common with chlorophyl, which is not found in these bacteria. The red-purple pigment, bacteriopurpurin, can easily be obtained in crystalline form.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

* Hans Molisch, Die Purpurbakterien nach neuen Untersuchungen, 95 pp. Published by G. Fischer, Jena, 1907.

# ASTRONOMY ON MONT BLANC.*

## PROFESSOR JANSSEN AND THE MONT BLANC OBSERVATORY.

BY H. RADAU.

IT is worth while to state briefly why the astronomers of our day have chosen to establish their instruments at high altitudes. When one has passed some time under an overcast sky, which obscures the light and renders all observations impossible, he recognizes the advantage of a station above the clouds. But even when the sky is perfectly cloudless the atmosphere is still a serious obstacle, for it is in fact a translucent and changeable veil between the observer and the heavens. This veil is very thick at sea level, and both distorts and changes the nature of the images of celestial objects. First of all, by its refraction it falsifies the position of the stars more and more as they approach the horizon, because the denser layers of the air form there a larger proportion of the path of the beam of light. Another inconvenience, more serious from the point of view of physical astronomy, is the diffuse reflection of the atmosphere, which causes a beam of light to illuminate in all directions the air it traverses. The light of the sky is a great obstacle to investigations of objects near the sun, and for a long time it prevented the observation of the solar prominences excepting at the rare occasions of total solar eclipses. It is now possible to view them in full daylight, thanks to Janssen's discovery of a method of enfeebling the diffuse sky light by the aid of the spectroscope, while leaving nearly unchanged the monochromatic light of the prominences.

Among the effects due to the presence of the atmosphere should be mentioned the absorption which it exercises upon the radiations of the sun and stars, for by retaining a portion of such radiation it profoundly alters the quality of the rays which reach the earth's surface. Not only is the intensity of the rays reduced by the passage through the atmosphere, but their composition is essentially changed. This is the reason why the sun appears red near the horizon, and it is also the cause of some of the dark lines in the solar spectrum, lines whose terrestrial origin is attested by their variation at high and low sun. These effects are much diminished when the observer stations himself at an altitude of several thousand meters.

At the summit of Mont Blanc (about 15,780 feet above the level of the sea) the barometer stands at about 17 inches, from which it follows that the weight of the atmosphere above is still a little more than half that of the entire atmosphere. Upon the highest peaks of the Himalayas the barometric pressure is only about a third of its value at sea level, where each square meter of the earth's surface supports a weight of about 22,000 pounds of air. By choosing a station at a great elevation the difficulties due to the presence of the atmosphere may be partly overcome. The measure of success which has already crowned tentative efforts in this direction has encouraged many who were hesitating to make the sacrifices accompanying perilous and costly ascents, and now we see mountain observatories multiplying and equipped with the most powerful instruments.

In his first ascent of Mont Blanc, in October, 1888, M. Janssen did not proceed beyond the inn at Grands Mulets, at the altitude of 9,300 feet, situated on the rocks at the junction of the Bossons and Tacconaz glaciers. At this time of the year the inn was already abandoned, and there had recently been a heavy fall of snow which had effaced the trail, hidden the crevasses, and rendered the ascent very difficult. Owing to these obstacles thirteen hours was consumed in reaching the inn by a route which in the favorable season is traversed in four hours, and the travelers arrived greatly exhausted. Accordingly, when two years later Janssen determined to try to reach the summit he discarded all thought of ascending on foot and devised a sledge somewhat similar to those of Lapland. The guides were ill pleased with this innovation; but at length, on August 17, 1890, Janssen left Chamonix in company with Durier and twenty-two guides and porters. Next day, while in one of the shelter stations on the route, a terrific storm burst and detained them three days. Finally, on the 22d, the weather moderating, Janssen continued the ascent with the twelve men still remaining, for the others had demanded permission to return. The sledge was finally hauled to the summit, and after some hours given to rapid observing in excellent weather conditions they resolved to go down.

For carrying on researches of considerable magnitude it is not practicable to depend on simple ascents, even frequently repeated; and it is indispensable to provide a permanent observatory equipped with a number of instruments and suitable for a stay of considerable length. M. Janssen represented this need strongly to the Académie des Sciences in his report of the expedition of 1890, and his appeal was not neglected.

The preliminary studies relative to the establishment of the observatory were commenced in August, 1891. They consisted, first of all, in the measurement of the thickness of the sheet of ice which covers the summit of Mont Blanc. M. Eiffel had promised to have these soundings made at his own expense and put them in charge of a Swiss engineer, M. Imfeld.

The summit of Mont Blanc is formed by a very narrow arête of rock, more than 100 meters long, running east and west. This arête terminates probably in peaks and has been imbedded in snow which has formed a crust thicker on the north side than the south, where it is more exposed to melting. Two horizontal galleries, each 25 yards long, were constructed about 13 yards below the crest without encountering rock, but only hard snow. It is therefore probable that the icy crust which covers Mont Blanc is more than 13 yards thick, and M. Janssen soon proposed a solution of the problem of construction in these novel conditions, which consisted in the laying of the foundations upon the permanent snowcap which forms the summit. All accounts of ascensions during the last century prove that the appearance of the smaller rocks near the summit has not changed much, and it may be concluded that the configuration of the top is being altered very slowly, if at all. It follows that a rigid construction securely anchored in position would be perfectly safe and relatively stable; but the question had to be settled whether the snow layer upon the summit offered sufficient resistance to support the weight of the structure. M. Janssen thought it necessary to make direct experiments to determine this.

During the winter there was erected near the observatory of Meudon a hillock of snow as high as a single story. The snow was rammed down until it acquired about the density of the snow on Mont Blanc. Upon the well-leveled summit was placed a pile of 60-pound lead weights. When twelve disks had been piled up and afterward removed, it was found that the depression had been only about a quarter of an inch. The result surpassed expectation and demonstrated the safety of the proposed building. If built on a rigid sub-base and provided with jackscrews, any strains which might arise by settling could be relieved, and the whole could be leveled as it might require. In order to guard against the fury of the storms, it seemed desirable to make the structure in the shape of a truncated pyramid and to bury the lower part in snow, so as to have a large and strong foundation.

The object being approved by M. Vaudremer, the eminent architect, member of l'Académie des Beaux-Arts, the construction was commenced according to plans prepared under his direction. It comprised two stories, with a terrace and balcony. At the base the pyramid measured 11 by 5½ yards. The underground parts

* Abstracted from Revue des Deux Mondes.

which form the lower story are lighted by wide but low windows above the snow. A spiral stairway communicates between the two stories and the terrace, and extends above the latter to support a platform some yards above, designed for meteorological observations. Double walls protect the observers within from the cold, and the underground part has a double floor separating it from the snow. The structure, entirely of wood covered by canvas, was set up at Meudon and then taken apart and transported to Chamonix. The total weight of the materials exceeded 15 tons and made 700 or 800 loads for the porters. As a precaution the route was divided into four sections. The first section, which comprised the route from Chamonix to the foot of the glacier, allowed of the use of the animals. In the second stage, ending at the public inn on the Grands Mulets, there is nothing but glacier, and the materials could only be transported on the backs of men. A shelter was constructed at Grands Mulets to serve as a depot of supplies and refuge for the porters. The trail from this station to the Rocher Rouge, which is about 300 yards below the summit, formed the third section, and there was constructed here a hut, for the carpenters and others engaged on the work to pass the nights and take refuge in case of bad storms.

All the summer of 1892 was employed in the construction of the observatory, its removal to Chamonix, and the partial completion of the mountain transportation; and in the year 1893 all was up, at a total cost of $8,000. An accident just failed of ruining the whole venture, for a depot of material, situated at Rocher Rouge, had disappeared by spring, and was finally found buried beneath eight or nine yards of snow.

For some months the great glacier of Mont Blanc, whose profile stands like a gigantic staircase, appeared like a woodyard with its files of porters, and the workers of the windlasses, which were placed from point to point to aid in moving the heavier pieces over the dangerous declivities. When the material was finally in place, the carpenters from Meudon began its erection, and, favored by a fortnight of calm weather, they were able to complete their work on the 8th of September. M. Janssen, eager to see the work, resolved to undertake another ascension, in which he availed himself of the windlasses this time to drag his sledge. He reached the top on the 11th, about midday, and remained there four days, occupied principally with observations of the solar spectrum, formed by a fine Rowland grating.

Janssen undertook another ascent in 1895, with the principal object of making sure that all the parts of the large telescope had come up in good condition, and were in shape to pass the winter without injury. This telescope is mounted in connection with a polar siderostat, so that its axis is parallel with the axis of the earth and receives the light reflected from the siderostat mirror. Both the mirror, of 24 inches diameter, and the objective were presented by the Henry brothers. All the adjustments are controlled from the observer's station, who thus has no need to move about, and may remain in a closed room kept at a comfortable temperature. This beautiful instrument was mounted not without some difficulty in 1896. M. Janssen also inspected the registering meteorograph, which had been installed in 1894, but had stopped. This instrument is driven by a weight of 90 kilogrammes, which falls 6 or 7 yards in eight months and keeps in motion a pendulum which regulates the motion of the registering mechanism. There is continuous registration of the barometric pressure, temperature, humidity, and velocity and direction of the wind. It proved that the apparatus lacked stability, and it ran after being given a support independent of the flooring, but the instrument has never gone very regularly. Another meteorograph, also designed to go eight months without rewinding, has been installed at Grands Mulets.

The problem of securing a very long running meteorograph suitable to be placed on a high mountain as a substitute for observations during the bad season is one of great delicacy, which requires further trials. M. Janssen is much interested in it and has proposed a new form, in which the rotation and fall of a registering cylinder is brought about by its own weight. M. Poncet, professor of horology at the college of Cluses, is engaged with the construction of a meteorograph of this kind. Up to the present time no registering meteorograph has been run more than eight or nine months.

At the time of this last visit Janssen made measurements to determine what, if any, movements of the observatory building had occurred since its erection. It proved that there had been a slight movement in the direction of Chamonix, but according to one of the builders this movement took place in 1893 and 1894, and afterward ceased. There appears to have been no very appreciable amount of settling, and at all events there are means provided for correcting this if it should occur; so that the fears and doubts expressed by Alpinists as to the safety of the observatory have proved unfounded.

## ENGINEERING NOTES.

**The boilers** of the "Lusitania" are divided into four groups in four different stokeholds. The products of combustion are carried off through four elliptical funnels, 130 feet tall above the grates and with a major inside diameter of 24 feet. The double-ended boilers are each 17 feet 6 inches in diameter by 22 feet long, and have 344 stay tubes and 720 plain tubes, making a total of 1,064. The total heating surface of one boiler is 6,593 square feet, and the grate area 169 square feet. The total heating surface of all the boilers is 158,350 square feet, the total grate area 4,048, which gives a ratio of heating surface to grate area of 39.1 to 1. It is interesting to note that the aggregate area of the grates in the ship is larger than two city lots, each 20 by 100 feet, and that the heating surface, 3.64 acres, is very nearly the area of a New York city block, 200 by 800 feet. The total length of each of the 25,536 tubes is 8 feet ⅝ inch, and if all the tubes were placed end to end they would extend for a distance of 205,086 feet, or 38.85 statute miles, 261 times the over-all length of the ship.

**The official full-speed trial** of the torpedo-boat destroyer "Sfendoni" (Sling), built for the Greek government by Messrs. Yarrow & Co., of Poplar and Glasgow, took place on Wednesday, October 16, in the Estuary of the Thames, in very rough weather, when a mean speed, carrying a load of 61 tons, of 31.825 knots was obtained over the measured mile, and 31.847 knots during a continuous run of three hours. The air pressure in the stokeholds was 2 inches, and the mean revolutions 490 per minute. The Greek navy was represented by Capt. J. Hepites, the chief of the commission; Mr. N. Leondopoulos, naval constructor; Mr. N. Sofikitis and Mr. J. Carpetopoulos, engineers. During a previous coal consumption trial of eight hours at a cruising speed of 14 knots, 35.8 knots were run to the ton of coal burned, giving a radius of action at this speed of 3,150 knots. The "Sfendoni" is the fourth vessel of this type built by Messrs. Yarrow for the Greek government. The dimensions are: Length, 220 feet; breadth, 20½ feet; and depth, 12 feet 4 inches.

**It is known** that chrome and nickel steels have a very high limit of elasticity and a great shock-resisting power. These alloys are relatively new, for they have been used in the steel industry for some ten years only. The addition of chromium to steel is made with the object of increasing its tenacity as well as its resistance to shock, at the same time that its lengthening under load is reduced. If five per cent of chromium be added, the tenacity is diminished, while the addition of nickel raises the limit of elasticity to a degree unknown at present, at the same time giving a remarkable power of resisting shock. The addition of nickel to steel up to eight per cent increases the elastic limit. The addition of more than fifteen per cent makes the steel very brittle. Silicon is sometimes added because it prevents the formation of blowholes, but it is not known how this action is produced. Phosphorus and sulphur are always present in steel. With a small proportion of carbon and a large proportion of manganese, a steel very easy to break is obtained. A chrome steel or a nickel steel containing a little carbon is very much sought after, because it could be very easily utilized; it allows very strong pieces having a very small weight to be obtained. In working this metal, it is necessary that it be equally heated and that it should not be overheated, for if this is done, it becomes impossible to get it back to its original state. The working of nickel or chrome steels is very difficult, but it can be successfully done if high-speed tools are employed. It is probable that if the use of this steel becomes general, the price will be quickly lowered.—Industrie Electrique.

**Electricity plays an important part** in the construction of the tunnel which is now being driven through the Hohe Tauern to connect Salzburg and Carinthia, a railway which will become important for the Austrian Alps. The operations are undertaken by the Austrian government. On the northern side, near Böckstein and Wildbad Gastein, turbines and steam engines have been put up; the latter have to actuate a tri-phase dynamo for 300 horse-power, which is to feed the fan-motors if the three high-pressure turbines, each of 180 horse-power, should fail. The drilling in the tunnel is done electrically and hydraulically. On the southern side two high-pressure Voith turbines have so far been installed, each of 600 horse-power, to drive two Krizik tri-phase dynamos for currents of 5,500 volts at 50 periods. The turbines run under a head of 150 meters. The power station is near Lassach, and the line is taken 3 miles across the mountains to the tunnel mouth. As lightning is very dangerous in these mountains, the arresters, of the horn type, are combined with an apparatus for earthing the line through water jets, a jet of water playing constantly upon each of the lines in the tunnel. The electric motors drive fans; the machinery for the air supply at both ends of the tunnel comprises 1,190 horse-power, of which not more than 620 horse-power is, as a rule, needed at a time. There are, further, electric elevators, a cable railway, and other machinery, and tri-phase currents are utilized at 110, 220, 350, 2,000, and 5,000 volts, in addition to direct currents of 550 volts. The chief power plant is to be permanent. —Engineering.

## SCIENCE NOTES.

**Five bauxite deposits** have been discovered in the island of Lesina, Dalmatia. They are reported to be of considerable extent, and are situated near the sea.

**The complete report** of the Census Bureau on the quantity of cotton of this year's crop ginned up to October 18 shows 4,407,055 bales and 24,934 active ginneries. In 1906 there were 4,931,621 bales and 26,125 active ginneries.

**According to the Engineering and Mining Journal,** chilled steel shot of extreme hardness and adapted to replace diamonds in drilling through many formations, is made by spraying or atomizing molten steel into cold water, thereby chilling it instantly.

**A new combination** of nickel and tin is prepared by E. Vigouroux, of Paris, to the definite formula, $Ni_3Sn$. It is formed by the method of fusion, and when in the state of powder has a light brown color. After standing in the air for some time the color becomes darker. When near the composition which corresponds to the formula, the mass after fusion has the appearance of bronze. This body is stated to be non-magnetic. Its density is 8.98. At a red heat it is acted upon by oxygen. When placed in chlorine gas it gives rise to a strong action, with incandescence. Hydrochloric acid dissolves it when hot in a very complete manner, and the effect of sulphuric acid is also rapid. However, nitric acid seems to have but little action upon it, even when hot, and in the case of the concentrated acid we find the appearance of meta-stannic acid. Potash in solution does not affect it, but fused potash has a corrosive action which takes place slowly. Summing up his present results upon the alloys of nickel and tin, M. Vigouroux finds that the alloys which contain up to 40 per cent of tin when acted upon by nitric acid and potash will leave a residue consisting of the present compound $Ni_3Sn$. As to the method used in preparing the new compound, the author uses a Schlösing furnace in which is heated a porcelain tube. In the latter is placed a magnesia trough containing a mixture of nickel and tin, the former in powder and the latter in the shape of grains.

**The "tumbo,"** a desert tree found only on the west coast of Africa, is a curious instance of adaptation to environment. The Journal of the New York Botanic Garden describes the mature "tumbo" as a "trunk" about two feet long, shaped much like an inverted cone. Almost all the trunk is below the surface of the ground, the visible part rarely exceeding a few inches. But the remarkable feature of the stem is that it is often 14 feet in circumference and becomes more or less two-lobed in age. The stem looks like a great mass of the burned crust of a loaf of bread. The underground portion becomes greatly elongated, and its continuation is the tap root of the plant. This goes down several feet in its effort to get the few drops of water that the arid conditions of the country permit. There are never more than two leaves after the seed leaves drop off, and very curious leaves they are. Starting from a groove on opposite sides of the depressed mass, they stand straight out on both sides of the plant. They are often six feet long and two feet wide, and usually split into ribbons that undulate over the ground in a way strikingly suggestive of the tentacles of an octopus. With its great ugly body and its tentacle-like leaves, it is no wonder that it has been the most remarkable plant novelty of the last century. The flowers are borne in scarlet cones on a cymose inflorescence coming from the crown of the trunk. Its African habitat is a region that seldom gets any rain, and desert conditions prevail almost completely, except for the sea fogs. The "tumbo" is thus a desert plant *par excellence*, and it is only by a close approximation of these very arid conditions that we can cultivate it.

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